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ABSTRACT

The topics of the 17 papers included in this proceedings are: (1) enriching and empowering young children's learning with microcomputers; (2) a program designed to make all students computer literate who complete the eighth grade in Tennessee schools; (3) how school systems should purchase microcomputers; (4) a team approach to microcomputer curriculum development; (5) ways in which a curriculum in BASIC programming could be used to develop skills that would have effects in other academic areas; (6) enhancing creativity through new technology; (7) computer learning environments and critical thinking; (8) aspects of matching the child, microcomputer, software, and manipulatives; (9) curriculum materials and activities to precede and accompany a child's earliest experiences with computers; (10) enhancement of basic skills of disadvantaged children by providing access to computers in the classroom; (11) young children's acquisition of keyboarding skills; (12) the use of computer assisted instruction with the physically handicapped student; (13) aspects of the physical environment to consider when integrating computers into classrooms; (14) computer camp experiences for the young child; (15) Logo and microworlds for children; (16) implementing Logo in classrooms; and (17) the Electronic Forum on Young Children and Computers. (RH)

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Proceedings of the National Conference on

MICROCOMPUTERS, EDUCATION, AND CHILDREN

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September 24-28, 1984

Nashville, Tennessee

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Preface

This publication entitled ***Microcomputers, Education, and Children*** compiles the proceedings of the national Microcomputers, Education, and Children Conference held in Nashville, Tennessee, September 24–28, 1984. The conference and the publication of these conference proceedings has been sponsored by the Business, Youngsters, Technology, and Education Consortium. Each presentor has furnished a paper documenting the session presented during the conference. This publication features the papers submitted, edited only for clarity and consistent reference style.

Because several sessions were primarily demonstrations of software, there are no formal papers available. The editors would like to acknowledge the valuable contributions of those presentors also. Dr. Pat A. Walkington, Educational Marketing Manager with Commodore Business Machines, provided interactive *Imagine* software, a language experience for young writers. Geroge Fincher, President of Consulting and Testing Associates of Chattanooga, Tennessee, demonstrated how parents and teachers could use the *MacPaint* software on a MacIntosh computer with young children, ages one and older. Gary Holt, Computer Technology Specialist with the Sumner County Schools, presented an overview of primary and elementary level software for the Apple Computer.

Rosemarie Vardell, licensing supervisor for the State of Illinois Department of Children and Family Services in Urbana, Illinois, and Carlo Werner, instructor of accounting and economics at the Granite City Center of Belleville Area College, demonstrated a new, locally developed program to provide preschool assessment in order to individualize curriculum. *Preschool Planner*, is a software program for teachers, trainers, and directors designed to: plan a daily schedule based on individual needs of all children; provide a variety of learning activities encompassing all early childhood curriculum areas; and facilitate parent participation in the education process. In addition to over 250 activities directly related to skill development, the *Preschool Planner* also includes an easy-to-use assessment scale to enable the teacher to identify the starting point for each child in each of the skills. This program is available for the Apple IIc or Apple IIe from Early Education Computer Dynamics, Inc., Box 311, Highland, IL 62249.

From the evaluations, we know that the participants in the Microcomputers, Education, and Children Conference took back to their classrooms an enthusiasm for the variety of ways microcomputers can be integrated into the learning process of children. We hope that the publication of these papers will further spread that enthusiasm to others who could not attend the conference, but who share an interest in the education of children in the future and the role which microcomputers can play in enhancing that education.

Barbara A. Nye, Ph.D.
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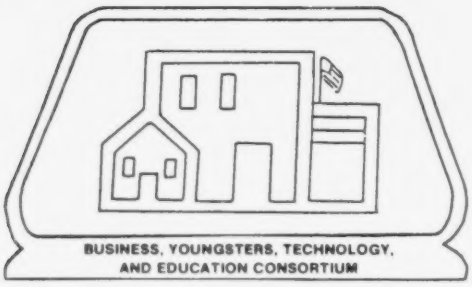

The Business, Youngsters, Technology, and Education Consortium (B.Y.T.E.)

The Business, Youngsters, Technology, and Education Consortium is a public service non-profit organization within the Tennessee State University Foundation. The B.Y.T.E. Consortium unites business and education interests for the improvement of education through the appropriate use of technology.

The programs and projects supported by the B.Y.T.E. Consortium are administered through the Center for Training and Technical Assistance of the School of Education at Tennessee State University. The B.Y.T.E. Consortium, through donations and grants made to the Tennessee State University Foundation, offers project services such as teacher, parent, and administrator training, child enrichment classes, research, conferences, and technical assistance through a variety of public-private partnership programs in the area of technology and learning. Some of the Consortium's current programs and projects include:

Project B.Y.T.E.—to train pre-school staff in the use of computers, particularly for low-income or developmentally delayed children (began 1982)

B.Y.T.E. An Apple A Day—a research and curriculum development project for kindergarten and first grade students in rural settings which includes a parent/home loan program (began 1985)

School Personnel Inservice Network (SPIN)—to provide training for public and private school teachers on integrating computer experiences in math and science in K-3 classrooms (began 1985)

B.Y.T.E. Commodore Resources in Education with States (CREWS)—Tennessee—to develop a teacher training model which will contribute to the development of a resource network on technology and education (began 1985)

Computer Appropriate Resources in Early Education (CARE)—to develop educational computing curriculum appropriate for young children featuring teacher as well as parent volunteer training (began 1985)

Technology and learning curriculum at Tennessee State University—a series of courses to enhance the preservice and in-service teacher training program (began 1984)

Technical assistance to colleges, universities, and agencies on technology and learning programs—to develop programs and conferences in improve teacher training and continuing education for teachers on integrating technology with the curriculum (began 1984)

Microcomputers at School, Home, and Work—a series of community service workshops on computer literacy, word processing, software evaluation, and computer experiences for children (began 1984)

The Consortium is guided by a national Board of Advisors from business, education, government, human service, and volunteer organizations. These individuals advise on implementation of technology and learning projects, review and suggest research, evaluate curriculum, and develop strategies for dissemination of information about technology and education. The distinguished members of this Board are:

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Barbara L. Bowen, Ph.D.

Microcomputers and Young Children: Enriching and Empowering Learning

Barbara L. Bowen ***is Director of the Apple Education Foundation of Apple Computer, Inc. Barbara has developed a grants program which makes equipment awards to school/university partnerships which design and implement applications of micros to enhance students learning and which include teacher training.***

Before joining Apple, Barbara was Manager of Training and Marketing Support for Logo Computer Systems, Inc. and was a consultant to the Computers In Schools Project, which implemented Logo in classrooms in three districts in New York City. Her involvement with computers in education began in 1980 when she was a Special Assistant to the National Science Foundation.

She has over 14 years experience as an educator in curriculum development, teaching, and teacher training in science, math, and early childhood education. She has been on the faculty of New York University, Queens College, and Bank Street College, and has five years teaching experience with young children. She holds a Ph.D. in Science Education from Cornell University.

Assumptions

What are the connections between computers and the assumptions we have about early childhood learning? As early childhood educators, our assumptions are based in large part on the work of Jean Piaget. Piaget was the theorist *par excellence* of children as builders of their own intellectual structures. Piaget studied and documented the development of children's thinking and reasoning related to physical phenomena, logical/mathematical relationships, and morality.

Children use the materials of the world around them and their interactions with adults and other children as the raw materials with which to build thinking. Their culture and the objects of that culture are the primary source of these "materials to think with and about." Where the culture is rich in materials with which to build thinking, children build well, and the structures and thinking they develop are stable and serve them well.

If the culture is poor in certain kinds of raw materials, the structures and thinking which children build are less stable and serviceable.

Computers are a powerful and increasingly more pervasive part of our culture. As early childhood educators, how might we think about them, and about young children?

Papert's Contributions

Any such effort must acknowledge the contributions of Seymour Papert. Papert can be considered the father of the reformulation of Piaget in light of the computer presence. In Papert's view, we must regard microcomputers as new cultural objects; rich materials with which children can build different kinds of thinking and create new relationships to knowledge.

What are the opportunities and possibilities which microcomputers offer to young children and to our work in early childhood education?

Let's look briefly at several examples of work with microcomputers and young children which the developers hold to be in the constructivist tradition. Our questions are: In what ways are these appropriate for young children? And in what ways do they enrich their learning environments?

Talking Screen Textwriting

A computer-based environment to support children's language learning and their writing and reading skills has been developed by Dr. Terri Rosegrant, State University of New York, Buffalo, and Dr. Laura Meyers, now at the City of Hope Medical Center. Rosegrant and Meyers are child development and language development specialists. They have developed the *Talking Screen Texturiting Program* (TSTP). *TSTP* is a child-appropriate text processing system which uses speech synthesis to provide children with information on sound/symbol relationships. In an experiment using *TSTP* with a group of non-handicapped preschoolers, the experimental group had access to a computer with TSTP, including speech synthesis, and a printer. The control group had access to pencils, paper, and marker.

The results: children using the computer with TSTP, produced richer language and more sentences and had a longer attention span than the control group.

Rosegrant and Meyers' work has been rooted in exploration and understanding of "What Fosters progress in learning to read and write?" Their work owes much to Halliday (1975). Their view is that the acquisition of beginning writing skills is similar to the process of the earlier development of language skills. In both cases, according to Halliday, Rosegrant, and Meyers, the impetus is functional. The child uses language and writing to do things she/he cannot do otherwise. Rosegrant and Meyers studied children who were having problems learning to read and write and they found that older non-readers and preschoolers had similar problems acquiring decoding and encoding skills.

TSTP contains important **scaffolds** to support beginners at the letter/word stage. It requires fine motor, visual,

auditory, and memory skills of the learner. It provides support and functions as a child's tool, to extend his/her range of functioning, allowing the child to accomplish tasks not otherwise possible.

The notion of **scaffolding** used by Rosegrant and Meyers **is not** at all the same as Skinner's notion of **shaping** (Skinner, 1938). Shaping involves a series of successive approximations to a task, starting with a much simpler version. For example, shaping of reading and writing is done by beginning with letter recognition and phonics and keyboard drill prior to allowing children to create meaningful text on the computer.

Scaffolding, on the other hand, supports the child in addressing the whole task. For example, speech output provides child feedback to let him/her know if words have been typed correctly. The child is in control. The childs' meaning is carried through language structures such as letters, words, and syntax. Such structures are secondary to meaning. The child is empowered to carry out personally meaningful long projects. Consonant with the language experience tradition, the focus is on the child's meaning.

Functional Learning

Another theme of Rosegrant and Meyer's work is that of functional learning. For the child, the computer-based writing has a purposeful use, i.e., communication with other children or adults. The writing is not just practice. In this context, the microcomputer offers advantages we cannot get in "normal" reading and writing activities.

The auditory modality of speech synthesis provides important feedback about written language. Visual and motor modalities are extended with added features of the microcomputer.

Some of research questions about the impact of the TSTP environment on the development of children's writing and reading competence which Rosegrant is exploring are:

1. Increase in risk-taking—one of the important bases of learning
2. Increases in exploration behavior and reduction in tentativeness
3. Role of feedback from machine and increase in feedback available from machine cf. other environments
4. How much more in control of learning contexts can children be? Research to date indicates that microcomputers are almost infinitely better in this regard than traditional paper and pencil environments.
5. The importance of multiple modalities, visual, auditory, and motor in supporting the child's learning.
6. The increased individualization possible with microcomputer-based environments

Programs for Early Acquisition of Language

The talking screen text processor grew out of work begun by Dr. Laura Meyers to investigate the effects of giving language-delayed toddlers synthesized speech. Meyers found that doing this greatly increased the youngsters motivation towards language learning and language use. This finding challenges the Chomskian comprehension model of language learning, in which language learning is viewed as primarily deriving from analysis of language input.

Meyrs' hypothesis is that active participation in dialogue is essential to language learning. Laura has developed **P. E.A.L, Programs for Early Acquisition of Language.** P.E.A.L uses technology to open worlds of language acquisition, play, beginning literacy, and communication to children with developmental age of 18 mos. - 5 yrs.

The themes which guide the development of P.E.A.L and Meyers' other work are **scaffolding, continuity** with child's prior knowledge, **empowerment,** and **cultural resonance.**

P.E.A.L provides children with control of multiple modalities, including speech output, colorful, playful computer graphics, and optional printed output. The program includes actual objects for children to use and explore as well as the graphics provided by the computer.

Meyers has had success with a variety of language disabled children, including children with down's syndrome, and cerebral palsy, as well as autistic children.

Microworlds

Dr. Robert Lawler is a senior research scientist at GTE Labs outside of Boston. Lawler was a student and colleague of Seymour Papert at MIT and was a special consultant to the world center for computing and the human resource in Paris.

Robert Lawler's work has its roots in the work of Piaget, Papert, and Kurt Lewin. Bob's work is focused on the development of computer microworlds which give children control over a little world of experience. In these microworlds, children use the numbers and words of the world to make things happen and to create interesting phenomena. Each microworld embodies a "Powerful Idea" from a knowledge domain such as language or mathematics, and supports and encourages children in the exploration and creation of interesting phenomena using that powerful idea. Children become engaged in using words with more power than usual.

The question which Lawler seeks to answer in the design of these microworlds is: "How to instruct while respecting self-constructive character of mind."

An example of a microworld which Lawler has constructed is "Beach World," a sprite logo-based microworld. In Beach World, words are used to create and control objects and actions. For example, typing in the word "sun" results in a sun appearing. Typing "up" moves the sun upward on the screen. "red" or "green" changes the color of the sun accordingly. Single words are used to perform either of two functions, creating an object, e.g., sun, house, jogger, boat, or truck or manipulating an object, e.g. up, sail, jog.

Other words can be used to change an object's location, direction, color, or to set it in motion.

The objects, once recognizable shapes appear, become the center of manipulative activities as members of a representational scene. In playful ways, as agents for **extreme action,** a sun can be made to "zoom" across the sky or children can create playful and **absurd juxtapositions,** such as putting a house and road in the water.

In these ways, the microworld becomes an alternative environment for language-drive dramatic play where the props are the graphic images on the computer screen.

Even more important is the child's ability to create new words, e.g., "zoom," "pine." The child can contribute to defining objects and attributes and adding these to the microworld. One of Lawler's daughters, Miriam, created an English/French translation of the Beach Microworld, "Le Plage." These microworlds use the computer to empower symbolic systems of language and number for children not possible with traditional materials.

The Constructivist View

Drs. Christine Chaille and Barbara Littman, University of Oregon, are child developmentalists in the Piagetian tradition. In recent years, they have been developing a series of microcomputer environments to enhance children's ability to construct physical knowledge. Their work draws on and extends the work of Kamiii and Devries in this area.

In the constructivist view, children learn about the physical world through theory building-based on experience. As they manipulate physical objects and observe the results of these actions, they hypothesize relationships between their actions and actions of objects.

They then experiment to test their hypotheses, and modify them as a result of effects observed. The key here is experimentation. Many physical phenomena are difficult for children to understand despite experimentation with them. This is so because the effects of the child's actions on processes and relationships may be inaccessible or ambiguous with traditional early childhood materials.

For example, a pendulum frequently swings too rapidly for children to observe its trajectory. The path of the trajectory provides information which is critical for the child in constructing knowledge relating the child's actions and reactions of the pendulum.

Traditionally, situations have been devised to provide reference points and additional information to the child. For example, bowling pins may be placed in a circle or semi-circle, with the pendulum in the center. The child can then assess the angle of the pendulum's swing in relation to placement of bowling pins. This yields important information for children to use in theory building.

Or sand pendulums may be used. The sand pendulum leaves a track of sand to mark its trajectory. This gives access to critical information which would otherwise be obscured by the speed of swing.

One of main tasks in the development of early childhood education curriculum is to give children access to relationships and information critical in understanding phenomena and constructing knowledge about those relationships. In what ways can microcomputers assist children in their construction with respect to relationships which may not be apparent or visible with traditional activities and materials?

Chaille and Littman propose that such techniques for making processes and relationships accessible to children can be effectively and feasibly introduced to children through computer simulations.

They have developed computer "microworlds" in which children vary a number of information-providing aspects of the physical world, which are difficult to control in an object-based environment.

One such microworld involves a train and ramp and "log launcher." As the train moves along the track toward the log-launcher, children must time release of log so that it rolls down ramp into designated portion of train as it passes log ramp.

Chaille and Littman use a series of what they call **Process Highlighters** to focus children's attention on essential parts of the process occurring between the beginning and end points. In this simulation, there are **three Process Highlighters:**

1. Permanent pathway in form of log ramp (trajectory)
2. "Ghost" or faded image of train left on track at moment child pushed key to release log
3. Freezing of all action at the point the log intersects the track

Chaille and Littman report that this last, has been one of most effective process highlighters and is obviously impossible in an object-based activity.

What Simulations Provide

Chaille and Littman hold that physical knowledge is logical domain for use of micros to support children in development of cognitive structures; the behavior of tangible objects can be portrayed with isomorphic structures in computer simulations. These simulations provide access to information which provides "connective tissue" for many real events.

Open-ended, child-directed simulations foster theory-oriented problem solving critical to acquisition of adaptive cognitive structures.

What are the implications of this view and this work for early childhood education? These simulations provide:

1. Meaningful application of micros to early childhood education where the goals are to enhance children's experimentation
2. Means for children to expand their repertoire of strategies and gain access to information which is functionally invisible in world
3. Potentially better physical knowledge activities for some phenomena

These simulations permit children to choose and control process highlighters. Computers extend experiences in ways not possible with other media and in ways which stimulate children's theory building.

Hakkanson's "Bubbles"

Joyce Hakkanson, founder of Hakkanson Associates, a software development firm in Berkeley, California has also made important contributions to the appropriate use of microcomputers with young children. Her group has developed several varieties of playful, gamelike software for young children including a "Bubbles" program which is used in conjunction with concrete, sensory experiences involving Bubbles. One of Hakkanson's primary goals is to use the microcomputer environment to unleash delight and joy.

Conclusions

Microcomputers are a new tool and a new cultural object which can contribute something of value and worth to early childhood education. I hope that these few examples will provide some ideas to think about and a sense of how this technology can be used with young children in ways that are developmentally appropriate and in ways which help us answer the question, "How can we instruct while respecting the self-constructive character of mind?"

C. Brent Poulton, Ph.D.

Computer Skills Next

Brent Poulton ***is Executive Director of the Tennessee State Board of Education which is responsible for policy planning and development for Tennessee schools. He is the former director of Project PENCIL (Public Education—Nashville Citizens Involved in Leadership), an innovative program to involve business leaders directly with an adopted school. He holds a Ph.D. in higher education administration from Michigan State University. He previously served at Tennessee State University as the director of the Center for Community Education and as an associate professor in the School of Education. He also has experience as administrator of adult education and testing programs in Montana and as coordinator of handicapped children's services in Utah.***

Computer Skills Next is a program designed to make all students completing the eighth grade in Tennessee "computer literate." A computer literate individual:

1. Has a knowledge of the components of a computer setup
2. Is aware of the history and social impact of computers
3. Can write simple programs, and
4. Can use the computer to operate various application programs such as word processing.

The four components of the program are:

Curriculum

A statewide microcomputer advisory committee, composed of educators from all levels and disciplines, developed computer literacy goals and objectives for elementary students in Tennessee. Governor Lamar Alexander and Commissioner of Education Robert McElrath and their staff proposed the Computer Skills Next Plan, which calls for the literacy training to be implemented first in grades seven and eight. A fourteen member writing committee, composed of eight teachers, three administrators, and three higher education representatives, took the goals and objectives, identified those to be taught first and wrote a teacher's guide for the first fifteen lessons. These lessons are divided into three, five-lesson clusters. The first five lessons (computer operations) deal with awareness, the history of computers and social impact. The next five lessons (logic and problem solving) introduce the student to simple programming. The final cluster of lessons (computer applications) deal with how computers are used.

Training

The State Department of Education will conduct a five-day training session for teacher(s) designated to provide the literacy instruction for seventh and eighth graders in each school. In addition, all other teachers in each school will receive a two-day training session designed to familiarize them with the literacy program and the hardware. This training will be conducted by state department personnel specifically trained for that purpose.

Hardware

The plan calls for the state to provide the entire cost of computers for each school housing seventh and eighth graders in the approximate ratio of one computer for every thirty students. The particular machine will be identified through a bid process. An approximate total of 4,500 computers will be purchased for the schools in order to fully implement the program.

Support Service

There are three major areas through which the state department of education will provide support to local systems as they implement the computer literacy program. Personnel in the nine district offices will also offer assistance as needed. A toll-free "Technology Hot-Line" will be established for local systems to use for immediate response to technological questions (1-800-538-1497). Finally, six software clearinghouses will be located across the state to assist local systems in the important task of identifying and evaluating software programs.

The Computer Skills Next scheduling arrangements can be grouped into two main categories. The first arrangement finds students receiving computer literacy training as part of a regularly scheduled class. Students in science, reading and mathematics, among other courses, spend 15 days of that class learning about computers. The second scheduling arrangement has students attending a computer literacy class for a set period of time (from three to nine weeks). These students are rotated to another class after that time and a new group moved in. The computer literacy course is generally grouped with pre-vocational courses, music, physical education and other "mini-courses."

The exception to these two basic scheduling arrangements occurs in two pilot schools where students attend a computer class once every two weeks.

Evaluation of the program consists of the statistical analysis of seven hypotheses regarding attitudinal and knowledge variables for students and teachers who have participated in the program.

Teacher attitudinal variables will be analyzed on a pre/post basis within the two-day training group and within the five-day training group.

Two instruments are being used in the evaluation of the program. One instrument consists of an attitude survey which is included in the fifteen lesson curriculum as pre/post assessment to be administered to each participant. In addition, the Minnesota Computer Literacy Awareness Assessment will be used as post-test instrument to ascertain knowledge and attitude statistics.

Information derived from the evaluation of the pilots will be used to determine the appropriate scheduling pattern for the future. Also, teacher interviews are planned to help determine how the teacher's guide can be improved.

Now that all four components of the program are being implemented, students in Tennessee leaving the eighth grade will be "computer literate."

Robert J. Evans, Ed.D.

How School Systems Should Purchase Microcomputers:

Robert Evans ***holds an Ed.D. in special education from the University of Virginia, and an M.Ed. and B.S. from the University of Miami in Florida. He has served as a classroom teacher in the sciences and special education, and has directed a group home for mentally retarded. He teaches special education courses at Troy State University in Alabama, as well as courses in microcomputers in education. He has recently produced two interactive video computer programs to be used in teacher training.***

Software Evaluation Method

The National Center for Educational Statistics reports that in 1981 approximately 31,000 microcomputers were in use in the public school sector. This figure increased to approximately 325,000 microcomputers in 1983 and is predicted to reach about 1.6 million by 1985 (Bonner, 1984; Emmett, 1983). More than half the nation's schools have at least one microcomputer. Unfortunately, many schools have just that: one microcomputer. Emmett questions whether or not these figures translate into a "microcomputer revolution" taking place in the public school system (1983). Emmett's statistics from the 1981-1982 school year indicate that of the 45 million precollege students in the United States, less than five million students had access to a microcomputer during that year, with an average of nine hours of use per student for the school year. He claims that these figures hardly justify proclamations of a "microcomputer revolution".

However, for a profession that took about two hundred years to accept books after their introduction (Schilling, 1983) and a system that does not reward the development of technology to improve classroom teaching (Lindenau, 1984), the teaching profession and public school system are definitely undergoing some dramatic changes. Public education has responded positively to the President's Commission on Excellence in Education, "A Nation at Risk" and its proposed "five basics" for graduation from high school which include computer science (Karoff, 1983). Clearly school systems are purchasing microcomputers in unprecedented numbers (Cohen & Schwartz, 1983; Power, 1983; Stallard, 1982; Taber, 1983). Administrators are no longer asking "if" or "when" computers are to be acquired (Power, 1983). Today's big question is "how":

1. How will our system choose the correct computer (Anderson & Senf, 1982)?
2. How will our system use computers (Anderson & Glowinski, 1982; Chandler, 1983; Grossman(b), 1983; Torgesen & Young, 1983)?
3. How cost effective are computers (Grossman, 1983)?
4. How can our system afford computers (Chandler, 1982)?

Curricula Needs Assessment

This paper will address the three major concerns associated with incorporating microcomputers into educational settings:

1. Computer use
2. Software selection
3. Hardware selection

The very first step of successful incorporation of the microcomputer into the educational process is the same essential component of desirable pedagogy, utilized in the incorporation of any effective teaching: educational aims need to be painstakingly translated into specific educational objectives (Abernathy, 1983; Rowntree, 1982; Wheatley, 1983). Before any further steps are taken, the educators involved must first determine their needs (Collopy, 1983; Noland, 1984; Rubin, 1984) completely divorced from the question of computer use. The teachers need to specifically identify the skills their students require (Carrozzo, 1983), and then identify the areas needing improvement in conjunction with the problems or difficulties they foresee in reducing the gap between the skills their students possess and their students' predicted needs (Carrozzo, 1983; Collopy, 1983; Thompson, 1983). The skills and/or subjects needed to be taught then need to be prioritized from essential to optional and viewed not only in the context of immediate requirements, but also projected over at least a five year period of time (Abernathy, 1983; Collopy, 1983; Fleig, 1983).

Computer Use Assessment

Only when educational goals are clearly determined should the possible use of microcomputers be entertained. Even then, it is still too early to be considering brand names. One now needs to begin the process of determining if the use of microcomputers in fulfilling the previously defined curricula and/or instructional needs will potentially obtain more desirable results than ones obtained by more traditional instructional methods (Lalm, 1984). If the use of microcomputers does not promise increased learning potential, then the use of microcomputers may not be warranted in the fulfillment of that particular curricula need. Microcomputers should be acquired only if they help to solve educational problems (Collopy, 1983). Frequently well written learning objectives clearly suggest the use of a microcomputer medium. However, if the objectives are such that a computer will not facilitate attainment, then the selection of any computer will be ineffective (Rowntree, 1982). Well constructed objectives will help determine the duties of the teacher, the duties of the students, and the instructional mediums necessary for both teachers and students to successfully perform their duties.

The classroom teacher is expected to be many things to many students at the same time: performer, subject matter expert, counselor, and record keeper to just mention a few. The computer can do some of these better, at least for some students (Schilling, 1983).

1. It can teach many things in many ways..
2. It can be very competitive or very cooperative.
3. It can be successfully used in structured as well as open classrooms.
4. It can be used with the "best teaching" methods as well as with the worst.
5. It can bore students as well as motivate them.
6. It can intimidate students as well as encourage them.
7. And it can threaten students as well as challenge them (Kleiman, 1984).

There are also many things the computer can not do for education (these lists are not meant to be exhaustive):

1. It can not decide what to teach.
2. It can not decide how to teach.
3. It can not choose the items and/or qualities to be emphasized by education.
4. It can not choose teaching methods and/or styles.
5. It can not choose how to organize schools and classrooms.
6. It can not choose the educational standards for students.
7. And it can not choose how to distribute resources (Kleiman, 1984).

The instructional staff needs to take the results of their "curricula needs assessment" and combine them with the capabilities of the microcomputer to develop the ways in which they will use the microcomputer. They will need to develop curricula that will integrate the computer into what they are already attempting to accomplish and simultaneously make full utilization of the availability of the microcomputer and its complete capabilities (Bonner, 1984; Emmett, 1983; Fleig, 1983). At present there are no real validated precedents for the efficient integration of the microcomputer into the established curricula alongside more traditional instructional procedures and/or materials (Bonner, 1984).

Four major potential instructional applications of the microcomputer are routinely identified (Duckenfield, 1984; Ewing, 1983; Ferret, 1983; Hagen, 1984; Katz, 1983; Karoff, 1983; Lahm, 1984; McClellan, 1984; O'Malley, 1984; Taber, 1983; Wheatley, 1983):

1. The microcomputer as an object to be studied
   a. computer programming
   b. problem solving
2. The microcomputer as a tool to help in ones work
   a. statistical analysis
   b. word processing
   c. control of laboratory instruments
   d. data base manipulation and searching
   e. communication network
   f. graphic use in the arts
3. The microcomputer as a teacher or tutor
   a. drill and practice
   b. tutorial programs
   c. curriculum oriented games (learning games)
   d. simulations
   e. logic and problem solving
4. The microcomputer as a management tool
   a. student schedules
   b. student academic records
   c. student attendance records
   d. student test scores

The instructional staff needs to select which of the above uses of the microcomputer is/are appropriate for their particular classroom, school building, and/or school system (Fleig, 1983). This paper will not make any attempt to evaluate the potential uses of the microcomputer. It needs to be a local decision, in order to help insure that the technology will serve legitimate instructional purposes (Collopy, 1983; Fleig, 1983; Fritz, 1984; Rowntree, 1982; Rubin, 1984).

Software Evaluation

Once the needs for and uses of the microcomputer are defined, they need to be clearly communicated in "plain English", not one's newly acquired "computerese to software vendors (Spokony-Smith & Smith, 1984). The careful selection of software is an extremely critical procedure that can not be taken lightly. In the final evaluation, it is the software purchased that will actually determine the use and effectiveness of your microcomputers in the instructional process (Fleig, 1983). Currently, a major impediment faces the unwary software purchaser. There is more "poor" software available than "good" software (Burke, 1984; Lindenau, 1984; Thro, 1983). Additionally, current software is "machine specific". Much of it will only operate on one or possibly a few types of the more than 200 brands of microcomputers currently available. Because of this situation, it is imperative that educators bring together the identified curricula needs and the identified microcomputer uses with their pedagogical training to select appropriate software before a decision on microcomputer brand and/or model is made.

Software is not only "machine specific", but each program is also limited to a specific purpose (Horn, 1983). At present, instructional software is a disordered array of disconnected activities which are not integrated into the curriculum (Emmett, 1983). One possible solution to this nightmare might be to have educators write their own programs. On the surface this can be a very appealing thought, until one considers the skills and time allotments required to produce a useful program. First, the teacher would need to be proficient in a computer programming language or authoring language. And second, the

teacher would require between 200 to 300 hours of programming time to produce a useful one hour instructional program (Emmett, 1983; Kontos, 1984). The teacher-would-be-programmer does not have the time to produce original programs. Software needs to be purchased. In order to purchase useful software, one needs to preview and evaluate it before purchase (Abernathy, 1983; Boyle, 1984; Christen, 1984; Edwards, 1983; Glassman, 1984; Lahm, 1984).

The user must accept the responsibility for demanding educationally sound programs through selective purchasing (Lahm, 1984). Only programs that have been exhaustively evaluated and found to be acceptable should ever be purchased (Abernathy, 1983; Appell, 1984; Boyer, 1984; Burke, 1982; Edwards, 1983; Glassman, 1984; Houston, 1984; *Peelings II*, 1984). Educators need to know prior to purchase that the software possesses educational value and that it satisfies an existing curricula need. Glassman recommends that failure to evaluate before purchase should be one of fifteen reasons to reject the purchase (Glassman, 1984). Two basic methods of software evaluation are available to prospective purchasers:

1. External reviews
2. Internal reviews

External Evaluations

Many educational journals and computer periodicals publish reviews of educational software programs. While these reviews may be used as potential screening devices to help sift through the large number of programs already available to educators, this method of evaluation presents some complications which must be considered.

1. Is the version reviewed the same as the one you plan to purchase?
2. What is the educational credibility of the reviewer?
3. What is the technological credibility of the reviewer?
4. How subjective is the review?
5. Are the curricula needs considered in the review the same as yours?
6. Are the users considered in the review the same as yours? (Taber, 1984)

A perfect match between the needs of the reviewer and potential buyers is very unlikely. Therefore, external reviews should only be used as a cursory means of identifying potential programs worthy of indepth review by the intended purchaser (Appell, 1984).

Internal Evaluations

Present software evaluation and acquisition are subjective processes. The selection and evaluation criteria need to be rigorously and behaviorally defined (Boyle, 1984). The most widely accepted method of operationalizing this concept has been through the development and use of software evaluation forms (Abernathy, 1983; Glassman, 1984; Kayser & King, 1984; Taber, 1984). Varying amounts of technological, motivational, and pedagogical criteria have been summarized and placed in a check list format (Boyle, 1984; Fleig, 1983; Katz, 1983; Kayser & King, 1984; Kontos, 1984; Lahm & Levy, 1984; Rosenthal, 1984; Taber, 1984; Thro, 1983). Unfortunately, many of these instruments have sacrificed completeness and clarity for brevity (Abernathy, 1983). Software selection is a long-term, expensive commitment that must not be entered into hurriedly. (Houston, 1984). Glassman states that software needs to be evaluated a minimum of three times before a decision to purchase is considered (Glassman, 1984). The total program needs to be examined, preview disks are not sufficient. If at all possible, it should be evaluated in the same environment in which it will be used (Kayser & King, 1984). Preview labs and/or software dealers willing to set up their equipment identical to your configuration (or intended configuration), supply an acceptable second choice (Edwards, 1983).

The software evaluation form selected should possess the following characteristics (see appendix A):

1. Request sufficient program background information to facilitate a purchase.
2. Present items which should indicate immediate rejection of the program.
3. Make provisions for the consideration of internal curricula needs.
4. Make provisions for the consideration of user population needs.
5. Make provisions for evaluating user conditions.
6. Make provisions for evaluating instructional methods employed.
7. Make provisions for evaluating computer presentation.

Educators can not afford to take short cuts. They must carefully select software that compliments their curriculum, is pedagogically sound, and is technologically sound. In order to do this, the software needs to be thoroughly and objectively evaluated before a decision to purchase or reject is made.

Hardware Evaluation

If the curricula needs assessment, the computer use assessment, and the software evaluation are completed in that order; the hardware evaluation procedure becomes relatively simple. Computer software is presently, and for the near future will remain, "machine specific". The software selected will dictate the brand of microcomputer required and also the peripherals required. It may seem simplistic, but the majority of effort expended during the process of selecting microcomputers should be divorced from the actual comparison of name brands and/or models. The identified needs and uses will identify the software required, which in turn, will limit the number of different machines from which to choose. From this "software dictated", some very practical considerations should help insure satisfaction with the microcomputer purchase.

One should select a machine that adequately runs the selected software; is currently available; and is supported by the manufacturer (Burke, 1984). Increased longevity of use may be obtained by identifying a company that enjoys the reputation of maintaining compatability when newer models are introduced. Also, the number of software titles available for a particular line of computer may sometimes be a valuable gauge of a company's soundness. Software authors will attempt to write programs for machines produced by companies capable of maintaining support for their microcomputers.

Ultimately the costs involved must be considered. Limited budgets mandate adherence to the "software evaluation method". If the instructional goal is identified as computer programming instruction, an inexpensive microcomputer with 3K memory would meet the stated need. While the purchase of a very expensive, larger memory microcomputer better suited for computer assisted instruction would be impressive, it could also be economically unwarranted (McLeod, 1983).

There is some evidence which suggests that school systems selecting fewer brands of microcomputers have moved

more smoothly and quickly towards computerization. However, this should not deter the use of the "software evaluation method" in the selection of microcomputer brands and/or models. Obviously, machinery which successfully facilitates the attainment of specified goals will be valued and, more importantly, used (Burke, 1984). It is the actual use of the computer which will insure satisfactory computerization.

Summary

The "software evaluation method" requires five steps:

1. Curricula needs must be identified
2. A "goodness of fit" between identified needs and computer uses must be determined
3. Software which meets curricula needs must be identified
4. Identified software must be thoroughly evaluated
5. The application of basic consumer considerations should be utilized in the purchase of microcomputers and peripherals which will adequately run the selected software.

That microcomputers should not be purchased from the top down should be glaringly obvious (Chorover, 1984). Administrators and/or policy makers can not choose hardware and then expect their teachers to figure out a way to make it work, simultaneously mandating that the system be integrated into the existing curriculum! It is an inefficient, expensive, backwards, and demoralizing approach to introducing microcomputers into the school system.

The microcomputer is a tool. Like most tools, the right one is necessary to do the job correctly and efficiently (Collopy, 1983). A sledge hammer is not needed to hang a picture! Any handyperson will attest that choosing the right hammer begins with ascertaining that something needs to be hit. Clearly knowing what needs to be hit, how hard it needs to be hit, and who will do the hitting, make for better hammer selection. The microcomputer is no different. In order to select the appropriate microcomputer, one needs to know exactly what needs to be done, what materials are to be used (software), and the characteristics of the individual to be doing the task (using the microcomputer).

Like any other tool, a microcomputer without a need or use will simply collect dust. While it may be an interesting toy for some, its value and use as a teaching aid will not be realized if it is purchased without a well planned purpose in the existing curriculum.

The actual selection of a microcomputer should be a relatively simple operation if the necessary pedagogical considerations which guide the introduction of any medium into the classroom are followed. Technically speaking, educator's should never experience "analysis paralysis" due to the continuous comparison of hardware specifications (Freifeld & Engelmayer, 1983). Educators should do what they are trained to do; what they are good at! They should identify educational shortcomings, identify remedies, and evaluate the materials needed to apply the remedies. This is the process which will insure the introduction of appropriate technology into the classroom.

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June Wright

Educator, Programmer, and Child: A Team Approach to Curriculum Development

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The educator's role is that of a decision maker. Each decade there are new methods and tools which are in vogue. Already the avant garde item of the '80s has shifted from the microcomputer to the videodisc. In the midst of a technological era, society will dictate our goals as educators unless we ourselves step back and analyze the purpose and validity of our teaching tools and strategies in light of what we know about how children learn. In the case of the microcomputer, the decision must focus not on a simple assessment of the tool (ie. the microcomputer and available software) but rather on the implementation of the tool. Karin Burg, a kindergarten teacher who resisted the initial influx of the microcomputer, and later found it to be a powerful tool, states the issue well:

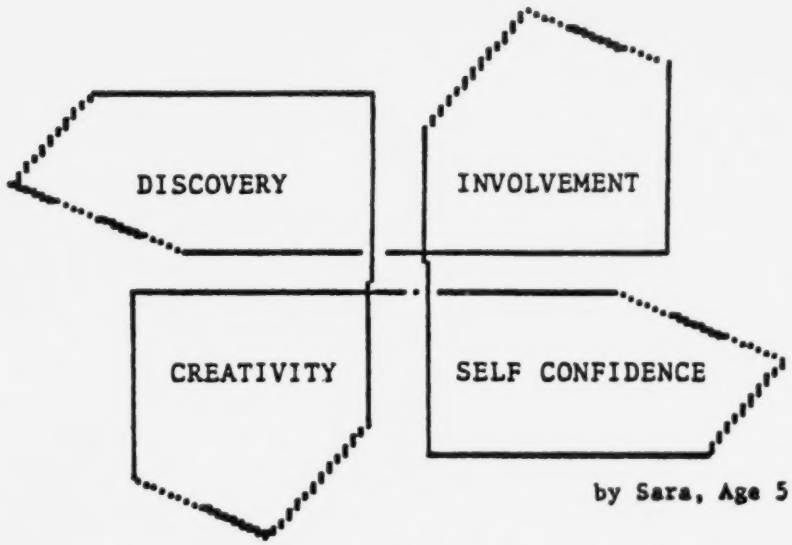
> All educational tools are value-neutral. They can be used to promote divergent thinking or conformity, freedom or restriction, self-confidence or fear. Choosing how an educational tool will be used is the responsibility of teachers. Such choices require knowledge. (1984, p. 30)

Matching an Innovation to a Philosophy

When microcomputer software first began to appear with the label "Ages 4-8", the staff at the Center for Young Children (CYC), a research facility of the University of Maryland, was very concerned that this new technology might not be appropriate for young children. Was it possible for the microcomputer presence to be a support to natural learning? Our philosophy clearly states that children learn by interacting with their environment, and based on this premise the children are provided a physical setting they can explore with a wide variety of materials to shape and change. How could they actively explore a microcomputer? The CYC philosophy also states that children are encouraged "to develop more awareness and understanding of themselves, of others, and of the world they live in" (Center for Young Children Annual Report, 1983, p. 22). Because microcomputers were rapidly becoming a part of that world, the Center staff decided to carry out an observational study of the children's interactions with the microcomputer. The purpose of the study was to determine whether children three to six years of age would benefit cognitively, socially, and emotionally from interacting with these machines.

During the first year of the Computer Discovery Project, the children were brought in pairs to a special Discovery Room. The children demonstrated that they could explore and begin to master this intriguing new technology. They commanded the machine using both the joystick and the keyboard. Working in pairs, they utilized the microcomputers to communicate their thoughts and feelings. They determined their own goals and often shared new ways of achieving them with their friends (Wright and Samaras, in press).

The second and third year of the project, the microcomputers were moved into the classrooms where they have become an integral part of the preschool curriculum. Based on insights gained from qualitative research, observational logs, and audio and video tapes of the children, a sequence of skills and concepts has been developed and a rationale regarding the meaning of computer literacy for young children have evolved. The emerging curriculum is named the DISC curriculum, an acronym which stands for the stages through which children move as they interact with the microcomputer: Discovery, Involvement, Self Confidence and Creativity.



by Sara, Age 5

One observation that effected curriculum planning was the realization of the rapidity with which the children assumed control of this new plaything. There are numerous incidents recorded in which the children initiate original interactions. Through playful exploration in a pressureless environment the children tried combinations of commands that might not have occurred if the learning environment had been highly structured and their objectives had been predetermined by the teachers or a curriculum.

This paper will focus on aspects of computer literacy the children demonstrated they can comprehend and the role the children can play in the development of a curriculum as they interact with teachers and programmers. Perhaps the discussion will raise the consciousness of educators and programmers regarding the importance of observing and interacting with the children for whom they plan and their awareness of the contribution the children can make in the area of courseware development.

A Smart or a Dumb Machine?

When the Computer Discovery Project began, children viewed the monitors as television sets and sat waiting to be entertained. However, one or two experiences interacting with a joystick and an open ended graphics program were sufficient to convince most of the children that here was a new plaything which they could control. They chose the color, the width of the line and the direction. As they drew they described their pictures: "super rabbit", "Halloween night", "the roads to my house", and "my big machine". One three year old boy drew with a joystick for twenty minutes and then moved on to explore the adjacent key pad which he discovered would allow him to change the hues of the design he had made. His teacher has assumed the key pad was too small and complex for three year olds to use. Sam taught himself by trial and error and then taught his friends. The keypad became an auxiliary choice adding variety to the drawing activity.

An inquiring four year old asked the teacher where the joystick connector went. The teacher opened up the Apple computer so that she could see how the joystick attached to the interior of the machine. "Oh, I see", she said. "Daddy told me it needed electricity. Those are the wires (referring to the sixteen pin connector). If it isn't plugged in it won't work, right?" A second child asked why her dad's new joystick didn't work right. The project director suggested that it might be connected backwards. Using her hand, the child said, "so he should turn it around like this?" She reported back the next day that she had told her dad how to fix it and it was working fine. The importance of electrical power was reflected again in the observation of a kindergartener who warned the teacher, "Don't connect the robot when the Apple's on; you'll blow it up!"

Not all of the children were equally aware. One four year old commented that a particular computer which wouldn't work was "sick". Her friend offered a less animistic interpretation when she asked if the monitor could work with a different computer. An experiment in alternative combinations of parts ensued. The opportunity to disconnect the monitor and attach it to another computer which put an image on the screen offered an experience in scientific experimentation and fostered a growing awareness of cause and effect relationships.

In each instance the child raised questions the teacher had not planned to address. Thus it appears that children can be introduced to this new technology without jeopardizing the self-constructive quality of their learning. The essential prerequisite to natural learning is not that the material be simple but that the teaching style be one of responsiveness to the questions posed by the children. In order to facilitate explorations, the teachers need to be ready to open up the microcomputer, insert peripherals, and hypothesize about the outcomes with the children. Such self-confidence on the part of the teacher can only come with teacher training and practice.

Sherry Turkle, in her chapter, "Child Philosophers: Are Smart Machines Alive?" (1984), discusses at depth the computer as a "new kind of object—psychological, yet a thing". She cites one child who could not turn off a faulty Speak and Spell and the mixture of fear and fascination he felt. A second child could not win against Merlin playing Magic Square and Tic Tac Toe. The child became angry and told Merlin, "You better give me an easy one or I'll hate you," yet when asked if Merlin were alive she replied, "No. It's the batteries" (1984, p. 55). Turkle suggests:

> Computers as marginal objects on the boundary between the physical and the psychological, force thinking about matter, life, and mind. Children use them to build theories about the animate and the inanimate and to develop their ideas about thought itself (1984, p. 31).

With the proliferation of video games, children are increasingly exposed to

computers as powerful machines which they must conquer. At the CYC the curriculum is planned specifically so that children do not experience situations in which there is competition or violence. These two factors would render the software incompatible with the educational philosophy of the school. An important criterion for software evaluation is that the program promote a good self-concept in the child. The children encounter "smart machines" that are programmed to remember their names. The impact of seeing her own name appear in a program is reflected in this incident:

> Computer Screen Display: "What is your name?"
> Child's Input: "AMY"
> Computer Screen Display: "Hi Amy. What color would you like in the first paint can?"

The child, delighted with the Screen Display went home and asked her mother who works with microcomputers:

> Child: "Mom, does your computer say 'Hi Gail?' "
> Mom: "No, Amy, it doesn't."
> Child: "Well, my computer says 'Hi Amy'. You better get yours fixed."

Two years later when her younger brother attended the same school and said he was using the computer to paint, Amy commented, "oh, I guess it says 'Hi, Cheo' now".

At the Center the children are encouraged to be in control of the machine. They know that to activate a response, they must push the return key to tell the computer to "do it". Judah Schwartz, who believes that the student should be in control of the "conversation" with the microcomputer, discusses the simple concepts children can learn about controlling a microcomputer:

For many children at CYC who know to push the return key, the microcomputer is viewed at times as a "dumb machine" because it cannot interpret a code which is not identical to the original input. If the saved name of the picture file is "John Graham", the input to recall it cannot be "JohnGraham". One typographical mistake renders the command invalid. From a four year old's perspective, that makes the machine dumber than his teacher or his parent who would have understood what he meant if he forgot a space. An interesting side effect of the precision required by the microcomputer is that four and five year olds soon recognize that words must be spelled exactly the same and will begin to check their input letter by letter.

The degree to which children become computer literate is influenced by two factors: the child's curiosity and the teacher's method of presentation. If a child asks how her picture is saved, the teacher can choose to respond with a simple statement, "it's on the disk", or she can carefully demonstrate how the disk spins and the light on the drive lights up. She can take out the disk and explain how it is divided into sectors like bands on a phonograph record. Then she can demonstrate how to recall the picture. The inquiry process is innate in young children. They have keen observational skills and a natural curiosity which can be reinforced at the microcomputer as in any other activity.

Children who grow up with the microcomputer as an integral part of the learning environment exhibit a confidence which astounds many timid adults. At age three, Kathy delighted in showing her mother and another parent how to use the microcomputer to draw. When she was five years old she decided to build her own microcomputer. The disk drives were fashioned from wooden berry boxes; the joystick was a popsicle stick inserted in a plastic basket; the cardboard keyboard had a carefully designed screen with a slot which made it possible for Kathy to insert various pictures because, as she explained, "the turtle doesn't always draw the same thing." Each peripheral was connected to the next by strings all of which were connected to the multiple outlet power strip. Radia Perlman, a teacher and researcher at MIT who has worked extensively introducing young children to the microcomputer, summarized the most important factor of computer literacy for young children when she said,

> The most important thing the young child learns in an imaginative computer environment is a fearless, joyful attitude toward learning. (1976, p. 8).

Kathy is a child who enjoys learning with this complex new tool.

Children as Critics and Creators

Among the early programs produced for young children was an alphabet program that accepted as input any key the child pressed and presented an image starting with that letter. It was a user friendly program which received good reviews. It did not pass the scrutiny of one of the four year olds at the CYC.

> Susie pushed the R key and a rabbit's head appeared on the screen with the word RABBIT under it. She pushed it several more times and the head moved about the screen. "It hopped but it's got no legs" commented Susie. She then pressed the A key and an Apple appeared. Unlike the rabbit, there was no label under the apple. Susie declared, "it doesn't say apple. How do you write 'apple'?" She tried to key in the word but the program accepted "P" and went on to display a prism. "Oh, Betty will have to fix it. I can't", declared Susie.

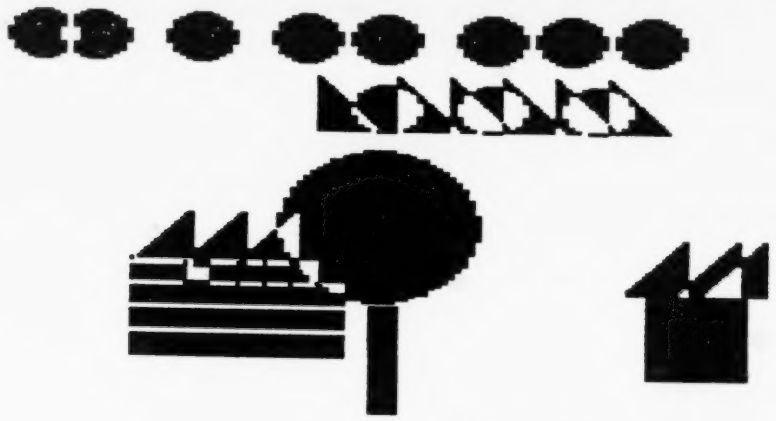
Who is Betty and how did Susie reach this level of awareness at age four? Betty is one of the programmers who writes programs for the children. Susie had seen Betty key in the commands when the class asked her to make big and little boxes of different colors. She reasoned that if Betty could draw boxes on the screen she could fix the new program to say "APPLE".

Programmers are frequent visitors in the CYC classrooms. Sometimes they create title pages in response to a name the class gives to a favorite program. Builder is a program with a shape index. The children can access a variety of shapes and move them into position to create designs and pictures.

When using the program, Sallie's four year olds requested that triangles facing in different directions be added to the index. They then named their version of the program "Sallie's Program".

The ability to interact with the programmers is an important experience which benefits the children, the programmers, and the quality of the software produced. In this atmosphere, children realize that the information (words and picture symbols) within a given program can be altered. In an information age, the understanding that information is not a static entity, but something accessed and acted upon by people is of crucial significance (Wright, 1984).

A feature of computer programs which surprises children and frustrates beginning adults is that the same key or button on a joystick may serve very different functions in separate programs. Having been told that John, the programmer, didn't use a particular button in Electronic Easel, an inventive child suggested what the extra button could



THERE IS A DOGHOUSE BUT THE DOG ISN'T IN IT. THERE ARE BIRDS IN THE SKY. BY EILEEN, AGE 5

do. As a result the children can now both create secondary colors by selecting primary combinations, and can draw with all of the colors created by moving through the paint cans with the hitherto unaccessed button. The program now incorporates the initial purpose of the teacher/designer and the programmerie. the simulation of combining primary colors to create secondary ones—and the additional goal of the children—to be able to draw with all the colors. An additional benefit of the revised format is that a new level of problem solving is presented. The children see six paint cans. They can reflect on which color is missing from an empty paint can and what combination of primary colors is needed to complete the set. Most four year olds successfully create two secondary colors. A few are able to process which combination of primary colors has not been executed and is needed to produce the missing secondary color.

The role of the child as evaluator becomes more complex when the program the child is critiquing is a commercial one that is write protected. When the children played with "Grandma's House", (Spinnaker, 1984), they quickly identified the most obvious problem, that the cursor moved too fast. As they played longer, other issues emerged, such as:

1. Grandma was hungry and there was no food in the stores.
2. The sportcar wouldn't move from the town but a bus did.
3. Grandma needed a garden for some of the gifts they brought her. They didn't belong in the house.
4. Grandma herself didn't move from one room to another.

If the children are encouraged to write their questions and creative ideas to the publishers and programmers, they will often reply. Young children expect a program to meet all of the conditions of an imaginary world they are creating. However, the microcomputer has limitations in terms of memory, graphic capability, and other technical considerations. Programmers can explain to the children that there are things the computer cannot be programmed to do. Recognizing the current limitations is a real part of computer literacy. Another insight that children accept more readily than adults is that different machines use different commands and that all programs will not run on every machine.

The Microcomputer and the Curriculum

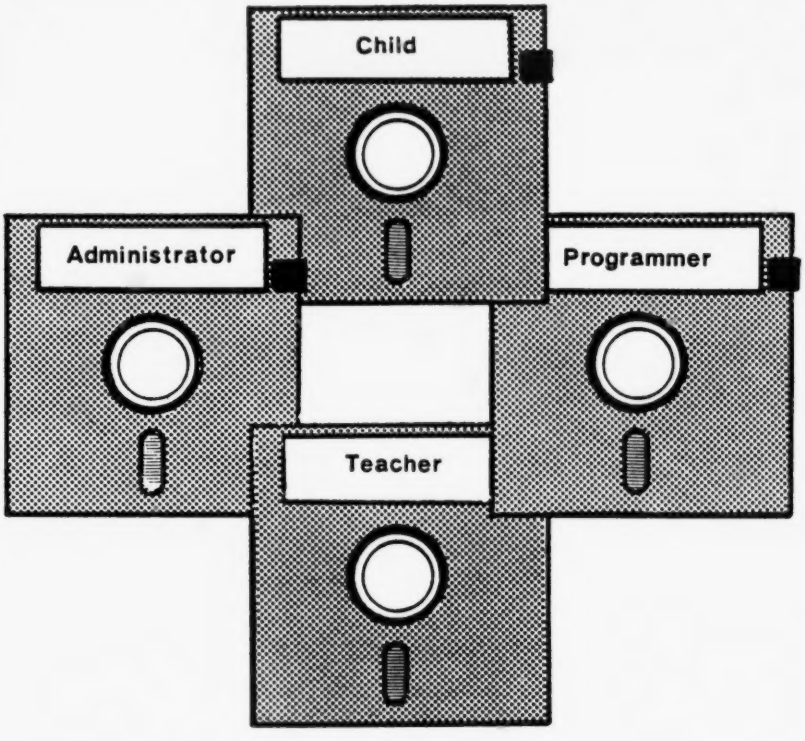
Perhaps the most meaningful way to integrate an emerging technology into the curriculum is to expose the child to as many of its capabilities as possible. The question to ask is, "what can I do with a microcomputer?" A five year old who knows that the microcomputer can be used to draw, to create music, to produce banners, invitations, and stories, to direct a robot and put together a slide show, is preparing to move into a world where data bases, word processing, and robotic production are the norm. If children and teachers have the opportunity to interact with programmers, whether they are parents, older students, or professionals, there is additional motivation to think about what is happening and whether there is a reason to change the design of the program.

Authoring languages which facilitate a teacher's power to interact with the contents of the program could be very helpful in attaining the goal of having children's ideas impact program design. At the present time, these languages lack sufficient graphic, animation, and branching capabilities. However, student teachers with a knowledge of Logo have demonstrated that they can employ Sprite Logo to create and edit microworlds for children. They involve the children in the creation of each world. Introduced to a set of dinosaurs that could eat, clump, and skip, the children immediately requested the ability to input how many times the dinosaurs did each activity. A simple scene with trees was insufficient for these young designers who thought dinosaurs needed a swamp to drink from, weeds to eat, sun, rain, and flowers. The student teacher worked from the chart which showed which child had requested each item. Word cards helped the children call up the procedures. The children gained practice in recognizing words and sequencing nouns and verbs to create action on the screen, and an increased awareness of their own ability and that of their teacher to determine what happens. Though not an authoring language per se, Sprite Logo offers teachers an opportunity to become a programmer creating animated microworlds that directly relate to the classroom curriculum (Martin, Heller, and Wright, 1985).

Speaking about software design for education, Walker and Hess comment:

> Technically elegant programs do not necessarily make effective educational tools. The success of a program hinges on a sophisticated knowledge of the user, on how he or she interacts with the machine, and on the effective instructional features of the software. A miscalculation of the capabilities of the user can be fatal; even good programs can falter or be ignored or ineffective if they disregard the principles that link the machine and the user (1984, p. 37)

The real measure of an individual piece of software and its integration in the curriculum will be obtained by observing



and listening to the response of the consumers which in educational computing are the teacher and the child. Until they are integral members of the teams which create, field test, and evaluate educational courseware, its quality and relevance will remain questionable.

What is the importance of the microcomputer in the preschool? Is it an essential part of the curriculum? Placing the role of the microcomputer in perspective is one of the challenges of the '80s. Research has shown that the presense of the microcomputer does not necessarily disrupt social interaction or traditional learning activities. Campbell and Schwartz point out that "the quality of the classroom experiences and the quality of the computer curricula to which young children are exposed are important variables in assessing the effects computers will have on behavior and activity patterns in the classroom (Campbell and Fein, in press). If a classroom lacks blocks or paint or books, the introduction of a microcomputer would be highly questionable. However, if a classroom is well equipped with materials that stimulate children's active learning and imagination, then the introduction of the microcomputer by a teacher who recognizes its potential is a valid decision. Douglas Clements, in a discussion of computers as a means to achieve education goals, not an end, states:

> The goals of early and primary education should be considered first. The computer is a *tool*, to be used to help achieve these goals. Although many of us adults feel that we need to cope with computers, that is not the need of children. Their need is to learn to communicate with people, to solve problems, to understand changes, and to handle information. For them, computers are a method of fulfilling their potential to grow in the world and with the world. Learning with and about computers is but one part of the optimal educational environment (1985, p. 10).

As early childhood educators, we can learn with our children as we explore together, the ever changing world of which microcomputers are a part.

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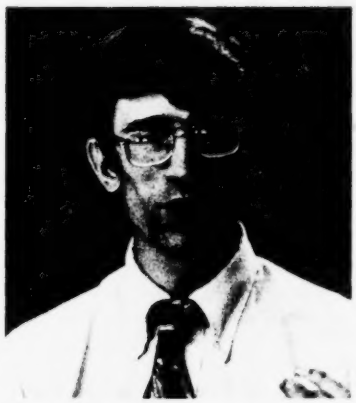
Mark S. Curtis and Ilene Cohen

Study Skills and the Microcomputer



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Students performing below potential frequently display deficiencies in learning skills such as planning, organization, sequencing, hypothesis development, and problem definition. This results in an inability to acquire new knowledge, to see relationships within and between knowledge bases, and to relate new information to existing knowledge. These missing skills are essential elements in computer programming. A specialized course in BASIC emphasizing observation, cooperative hypothesis development and testing, problem analysis and definition, and utilizing a highly stylized structure for program development was created for a pilot project involving middle school students. Based upon the Ausubellian "assimilation theory" and recent extensions of these concepts by Charles Reigeluth, structured models for knowledge acquisition, planning and recall/application were presented. The skills acquired were found to have significant carry over value applicable to a broad range of academic endeavors. Improvements in motivation and general academic interest were also observed in the test group and attributed to the self-confidence gained from successful meeting of challenges, possession of new skills and the positive reinforcement of social cooperation.

Statement of Beliefs and Purpose

Two years ago at the founding of the cross-divisional Computer Studies Department of St. Paul's School, we took the following statement as our guiding principle:

To the extent that we teach only facts,

To that extent we fail to educate.

We view the purpose of computer education not only to be the instruction of our students in a field of technology that will have significant influence throughout their lives, but also as a methodology for expanding their experiential base and their perceptions of the world around them. Tacit within this conceptualization of the role of microcomputers in traditional educational settings is a belief in the liberal arts approach to computer science. The micro-computer is a tool that can be used to extend the hand of man deeper into the essence of his own being. We believe many of the skills inherent in systems use and programming are of a general nature with applications in many other areas of learning. This sense of carry-over skills and our desire to identify the nature and extent of their commonality led us to initiate a pilot study in the spring of 1984. This study was designed to identify the ways in which a highly structured curriculum in BASIC programming could be used to develop skills in data organization, problem definition, and problem solving that would have positive carry-over effects in areas of academic study outside of computer programming.

Study Goals and Objectives

In the face of scheduling difficulties, small student population, and available hardware, we decided to maximize our resources and specialize our study within specific parameters. One member of our computer faculty holds a Master's degree in remedial reading and study skills development. We have a Study Skills curriculum directed by a qualified specialist. In addition, over the past few years, we have developed an unusual approach within the Computer Studies curriculum under the current Director of Computer Studies to the instruction of structured programming independent of the computer languages being taught in any given course. Since our interest lay in determining if computer education could be shown to have positive effects upon learning in general, it seemed natural to combine the study skills course with our modified approach to instruction in computer programming.

We narrowed the areas of particular emphasis to two main objectives. A careful analysis of the actual procedure of

programming reveals that the critical aspects in program development are:

1) organization of known information
2) problem definition
3) analysis and sequencing
4) synthesis

We further recognize that these steps were by nature a linear organizational process with clearly defined beginning points, observable and necessary sequential patterns, providing results in a self-presenting and non-judgmental event representing an unmistakable closure for the exercise. The skills necessary to follow this process encompass many of those used by successful students in day to day study habits or in preparation for a test. The analogy existing between writing a program and taking a course is remarkable from the perspective of the process necessary for success. It became the goal of the pilot program to delineate some of the aspects of this process that could be reinforced through computer education. Throughout the study development and the administration of the project itself, we emphasized an approach which we called "process stressing." At all times, the central thread of the project was the "process" of achieving the final result. This process was presented repeatedly in individual project design, teacher method, class discussion, and coding structure. An unusual aspect of this was that the process was both a model for the students to emulate, and the "new knowledge" that was to be made meaningful to the students through instruction.

The second objective of the project was to determine if problem solving strategies presented in association with specific programming projects could be seen to provide models for problem solving in other academic areas as well. We felt that the process one goes through for finding an answer to a problem was inherently definable as a choice of one of a few general approaches with applications to many specific areas. The approaches selected for presentation and student experimentation were:

1) trial and error
2) exhaustive listing
3) trial and adjustment or analysis/synthesis

Experimental Subjects and Methodology

The experimental group chosen consisted of middle school aged students who, in a few cases, had diagnosed learning disabilities, but for the most part manifested lower than expected academic performance with no discernable learning difficulty as evaluated by I.Q. and aptitude testing. In general, the subjects displayed a distinct lack of organizational/planning skills due to a variety of reasons and were referred to us by classroom teachers who categorized them as under-achievers.

Logistical and philosophical factors made a standard experiment with pre- and post-testing, control and experimental groups, and a design to generate statistically significant data both impractical and generally undesirable. Instead, we opted for a subjective evaluative procedure that would permit a more organic and flexible administration. This permitted us to modify on a session to session basis the nature of presentation or the programming projects assigned without fear of compromising the integrity of statistical data. On the basis of the results of this methodology, we are considering ways of standardizing our project to provide some of the objective data that we were unable to obtain in the initial study.

Central Learning Theory Concepts

Dr. David P. Ausubel has stated:

> If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly. (Ausubel)

This statement is central to the concepts in Ausubel "assimilation theory" of learning. It is also a philosophic progenitor of the ideas expressed in Seymour Papert's *Mindstorms*. In his forward to this book, Papert states:

> . . . the "laws of learning" must be about how intellectual structures grow out of one another and about how, in the process, they acquire both logical and emotional form. (Papert)

In each case, the emphasis of the individual authors is on ways in which a learner's existing knowledge base can be used to facilitate the acquisition, retention, and application of new knowledge in an efficient manner. In recent work, Charles Reigeluth has taken the Ausubellian concepts and expanded them to expose a number of inherent structures. Briefly, Reigeluth identifies seven kinds of prior knowledge and associated techniques for using this knowledge to good effect. These are: 1) arbitrarily meaningful knowledge; 2) superordinate ideas; 3) coordinate ideas; 4) subordinate ideas; 5) experiential knowledge; 6) analogic ideas; and, 7) cognitive strategies. Various of these act: to relate the new knowledge to existing knowledge within an area of content; to relate the new knowledge to existing knowledge outside of an area of content; or, to develop generic skills. (Reigeluth) The learners in this study demonstrated a lack of the generic skills necessary for success in academic pursuits. Our purpose was to develop these skills. We needed to tap the existing knowledge base, develop new and logical relationships between the elements of that base (the existing knowledge) and provide an opportunity for the learners to acquire specific additional elements (new knowledge). The "new knowledge" could not be of a factual nature, but rather elements of the "process" of learning that creates "contact points" and "access pathways" facilitating the acquisition of knowledge in meaningful ways. Thus the emphasis of the project was in the area of "cognitive strategies", making systematic use of superordinate, coordinate, and subordinate ideas and the learner's experiential knowledge base.

The framework for the curriculum was based on the presumption that the learners possessed some knowledge necessary for success, but lacked an organizational structure (the "ideational scaffolding") needed to perceive relationships between the elements, to use their existing knowledge in logical ways, and to apply the varied elements in tasks other than in rote manners. We were not attempting to make great increases in their knowledge base by providing additional facts (arbitrary knowledge), but rather, by providing models for using the existing base more efficiently. These models were cognitive structures and strategies that could be used by the learner to make new knowledge meaningful, to elevate more of the knowledge base from a "remember" level to an "application" level, and to increase retention and recall.

Method of Instruction

The pilot study covered 11 weeks of

instruction with classes held on the average of every other day. Several programming projects were devised and presented to the students in a systematic manner. Applesoft BASIC was selected as the programming language due to its availability. It should be noted that we believe that the particular language chosen for instruction is inconsequential. LOGO, PILOT or PASCAL could just as easily have been used. The central question is one of process. Our intention was to provide models of the "process of learning"; *i.e.*, the organized, sequential procedure that represents an efficient method of acquiring knowledge in a meaningful way by systemizing a structured approach to data organization, problem way by systemizing a structured approach to data organization, problem definition, and event sequencing, ultimately leading to problem solution. Since this process is independent of the language ultimately selected for coding, most programming languages lend themselves equally well to the purposes of this study. The pre-coding process and the actual program structure was believed to be far more important than the language used since they are themselves cognitive models representing the actual new knowledge that was being taught.

The initial projects in the curriculum consisted of presenting complete programs written in BASIC that were generated or modified by the Computer Studies faculty. These exercises required the learners to: observe events; gather information; relate the new data to their existing knowledge base; and then develop and test hypotheses for solving the problems presented. An example of this type of project was a program which generated a 10 by 10 grid with three hidden spots randomly selected by the computer. The apparent task for the students was to determine the locations of the three spots. After the selection of a test location, the program would respond with the distances of each of the random spots from the test location. The students would repeat the testing process until all of the locations had been determined. The actual task of the experiment was to discover a method for finding the locations in the fewest number of trials. The solution lay in the understanding of the relationship between the reported distances and the test locations. The experiments were conducted by having the students work first as a single group, sharing ideas and insights, and then as teams of two students. At first, the students predictably tried a trial and error approach to the solution. Later, following discussion, the students began looking for patterns in the distances reported and their relationship to the test location. Compasses and graph paper were offered to the students as potential tools. Shortly after this, the students began to discover the rudiments of triangulation and the number of guesses made declined significantly.

Observation and data gathering were selected as initial tasks based upon the presumption that the learners lacked basic structures for relating information (both old and new knowledge) in meaningful ways. In Ausubel's terms, they knew something about location and distances, but lacked a meaningful understanding of what these facts meant. The process of gathering data and then relating the various elements to each other and to existing information in the knowledge base demonstrated a model for approaching this problem at a level above "rote" and "trial and error" concepts. The cognitive structure of looking for relationships and then responding to them, introduced functioning at an "application" level by superordinate, coordinate and analogic means.

Following the observation projects, we presented a series of problems that required programming in BASIC to achieve solutions. Each new project was introduced in terms such as, "If we have an area of the monitor screen of known size, and we repeatedly pick random locations within the area to change to a different color, how many times will we duplicate a previous pick before the entire area is changed to the new color?" This type of experimental questioning was intentionally selected for the purpose of capturing the interest of low motivation students as well as to present a problem with easily definable solutions. Care was taken to ensure that each project had aspects of broad applicability to other areas of study. The above example is not only an interesting question in its own right, but touches upon the ideas of probability and statistics, random number touches upon the ideas of probability and statistics, random number generation, and graphic representation. Other projects involved rudimentary trigonometry, number guessing strategies, and dice rolling simulations.

After each project was introduced, group discussions were held for the purpose of determining what was involved in the question, what the known information was, what had to become known before the project could be begun, and ways by which the problem could be solved. Simulations using graph paper and pencils or other suitable props were carried out to help the students develop a concrete concept of the problem and to aid in problem definition. The next step was to "write" the program in the language the students knew best, English. At this time, much emphasis was placed upon the idea of breaking the problem down into small, better defined pieces. The concept of "process stressing" was a significant aspect of the instructional method during all of these projects. The same step by step refinement of the problem from the collection of known facts to the English description of the solution was used each time. This again was done to provide a model for the process of learning that was reinforced by consistent and constant repetition.

Once the problem had been defined, analyzed, and refined into steps, the actual coding step was begun. Only at this time were language specific details pertinent to the English version of the program presented. Commands and data representation methods were introduced as necessary, and syntax and editing problems were facilitated by the use of a program editor.

It is significant to note that a simple but effective program editor, while seemingly of only peripheral value in terms of convenience, made a significant contribution to the overall project. The need to make many modifications to lines of code is normal when introducing programming to a student, and a program editor reduces the tedium of this. But, more importantly, an editor is a system characterized by an architecture, options and sequences. The lack of an organizational cognitive structure leads to a limited ability to sequence events. The editor is an additional model working at a concrete level for reinforcing a logical process and the general organizational cognate. LOGO, versions of PILOT and other language systems possess adequate editors, but APPLESOFT BASIC

needs to be extended in some way to accomplish this effect. A careful selection of one of the many co-resident RAM based editors is highly recommended.

After the first projects were completed, individualization of programs along personal perceptions of the project at hand were encouraged and group discussions of the various solutions were held as a means of demonstrating the fact that not all problems have only one solution. There was much value gained from the realization by the students that some solutions were more "eloquent" than others, even though they all could be shown to have produced comparable results.

The peer cooperation aspects of this study are significant. The development of an atmosphere of sharing and mutual support permitted the students to voice individual ideas about the nature of a given problem with diminished risk of negative peer reinforcement. This in turn provided an opportunity for each student to participate in the generation or realization of the new knowledge necessary for the problem definition and subsequent solution while removing the burden of having to acquire all of it independently. This was an important step since most of the subjects initially lacked the skills and process structure required to do this individually. The carefully monitored group activities provided another model for the students to emulate in later course projects involving more individualized work.

It needs to be noted that language specific details were not necessarily presented in what might be termed the "normal" order. As an example, the concept of single dimensioned arrays was introduced in one of the first programming projects. The questioned posed was, "if we rolled a pair of dice a given number of times, how many times would each of the possible sums of the pair be generated." The "best" solution involved the use of a single-dimensioned array with the individual elements representing the possible sum results. However, the first student solutions suggested used only simple alphanumeric variables, conditionals, and counters in conjunction with the random number generation. While involving a great deal more coding, these were found to produce the desired output equally as well. Arrays are frequently viewed as far too abstract to present to beginning programmers, but with careful lead up, making extensive use of pictures and diagrams, and concrete models presented through analogic concepts to families, the students were able to quickly grasp the idea and to use it in subsequent projects with assurance. (Evidence that the new knowledge had become meaningful.) Case statements, graphing commands, and two dimensional array manipulation can similarly be easily learned when presented in conjunction with a well defined problem and a thoroughly refined English language representation of the program. LOGO with its structure of lists and list manipulation primitives would support this type of project successfully with younger students and would serve to introduce the concept of arrays as a type of data structure well before this concept is generally thought to be appropriate.

In the selection of the programming projects, care had been taken to sequence the tasks by the required/available language primitives so that the learners would be exposed to new concepts (knowledge) in a manner reinforcing the organizational model which was at the heart of the new knowledge being presented. The first project needed the use of simple conditionals of the "IF . . . THEN" nature. This structure is a natural part of the existing knowledge base (the English language) and its use required only the coordinate idea of branching which is analogous to real life decisions. This was expanded to introduce the ideas of a "counter loop" and "counter" variables. Once this was a meaningful element of the knowledge base, the idea of the "FOR . . . NEXT" loop structure could be introduced with the counter-loop as the coordinate idea. The initial use of the "FOR . . . NEXT" loop was in a simple "do this section of code this many times" application. After this, the idea of using the index values of the loop to control program results in different ways was introduced. This was done through a lo-res graphics project that created die faces on the screen as an extension of the dice rolling question posed above. "FOR . . . NEXT" loops were used in sub-routines to setup the screen, create and erase the die face, and to place the spots of the die on the face. This required the learners to generalize their understanding of loops into a new application and represents one of the higher levels of meaningful knowledge usage. This systematic relating of existing knowledge to new ideas to increase the degree of meaningfulness and subsequent expansion from these new points of knowledge in the acquisition of additional knowledge is essential in all learning activities. It was all the more important in this study since the learners in question lacked the skills to establish the necessary relationships on their own. This systematic approach again reinforced the concept of the "process of learning" and contributed to the overall acquisition of this process by the learners.

Program Structure

In accordance with our stated objective of providing a model for approaching any given task requiring organization of information, it was essential that a highly structured method of coding be presented that would reinforce the structure of the process followed to arrive at the point where coding could begin. We devised the following structure which we insisted be followed in each programming project involving more than two clearly defined modules. The shell below is not unique in many ways, though it is highly system specific in terms of the Applesoft interpreter logic. We specifically decided to avoid the more traditional "top-down structures" in the longer projects which are generally recommended by most instructors. We wanted to create a structure which would inherently have concrete locations for specific types of code segments. We believe that this stylized structure helps students to group information by type or function and thus reinforces the idea of finding similarities in concepts that would help to clarify the relationships between them. At the same time, this further reinforces the idea of modules or "a guy hired to do one job excellently well." By its nature, a module is an organizational structure that groups events or information of a highly similar nature. They also have clearly defined relationships to other modules in a program. These characteristics make modular structured programming a natural model for the learning process. Tangentially, it makes it an easy task for a student to remember where to look in the program in order to find a problem or to initiate a modification.

The programming format was itself introduced to the students by making application to the analogic prior knowledge concept. The idea of a business and the task performed by the various employees of a business was used. Some employees are hired to do work of a specific kind, while others are the decision makers with various ranges of authority. By encouraging the students to think of their proposed solutions in terms of specific tasks, the problem definition and refinement steps during the pre-coding stages were facilitated. In general terms, a model for breaking down problems in broad areas of interest was thereby reinforced furthering the development of the cognitive strategy and ultimately the study skills which this strategy represents.

The structure used for the projects was as follows:

LINE #	TYPE OF CODE
10	Branch to title page and initialization module Branch to main or executive module
EXAMPLE:	10 GOSUB 20000: GOTO 1000
20 To 999	Often done sub-routines and specific sections of code designed to do "one small job excellently well"
EXAMPLES:	End of page routine Print center routine Random number generators Graphics page routines
1,000 To 2,000	Main or executive program, the "Company President"
Up To 10,000	Secondary decision makers, the "Vice Presidents"
20,000 To 30,000	Initialization module and title page generator
EXAMPLE:	Array creation Variable initialization Set display pages
30,000 And Up	All data lines, if any

Results

The subjective evaluation of this project reveals insights into three main areas of further study. These are: 1) the individual personal growth of the students involved derived from the socially supportive environment of the pilot project; 2) the organizational and planning skills gained by the students; and, 3) the carry-over skills pertinent to other academic areas.

In the area of personal growth, there was a significant change in the self-confidence, motivation, and general academic interest displayed by the learners in this project. Observations of these changes were reported by the classroom teachers as well as by the subjects themselves. We concluded that much of this change in attitude could be attributed to the degree of personal success that the students experienced during the project as a result of the atmosphere of cooperation which was carefully planned for by the project developers and created by the project instructor. Mistakes and the resultant "debugging", both of code and logic, were handled in an atmosphere of social supportiveness, and dealt with by the project instructor as valuable learning tools rather than as evidence of individual failure. All of the learners participated in a social process of developing problem solving strategies, and as a result, each could feel that he had been a valuable part of the overall success of the group. Common errors made by the group were pointed out and the stigma of making a mistake was lessened. Experimentation and risk-taking were thus encouraged and individuals felt freer to express their points of view. As an example, a common error early in the programming projects was a failure to reset a counter or flag variable to an appropriate value. The group was encouraged to view the oversight as a foible and those who had trouble with the elements of sequencing and planning that this mistake was a product of were insulated from a general disapprobation that would have resulted in a more traditional setting. The boys could laugh at each other good-naturedly. But the principle was reinforced and subsequent programming projects gave each student ample opportunity to either make the same mistake or demonstrate that the concept had become a meaningful element of his knowledge base. This atmosphere of cooperation and sharing virtually eliminated the traditionally painful isolation of learning that had become a too common experience for many of the students in this study. It is no secret that success increases self-confidence and motivation. As the success rate of the group centered projects became apparent to the subjects, each student began to feel better about himself and about the group that he had become associated with in the minds of the general student population. One typical comment was, "Study skills class is fun after all," Admittedly, the "halo effect" contributed to an increase in participant pride as other students became aware of the innovative nature of the new study skills class, but it was felt that the individual growth observed could not entirely be attributed to this single factor alone. Rather, the inherent desirability of this atmosphere of cooperation in any learning situation became clear to the project directors as a significant factor contributing to the process of making new knowledge meaningful.

The growth in the area of organizational and planning skills and in the development of cognitive strategies for approaching problems was also viewed as evidence of the success of the pilot study. Each exercise was purposefully planned. A careful analysis of presumed prior knowledge, event and task sequencing, and programming concepts, both general and system specific, was performed well in advance of administering the curriculum. Projects were sequenced on several levels of content and concept, with successive projects to reinforce previous ones. New knowledge elements were introduced in judicious ways throughout the project with student preparedness an essential factor governing their introduction. The presentation of single-dimensioned arrays is an example of this. The dice-roll project was first solved with conditionals and simple numeric variables. The group determined that this was a tedious way of handling the problem. As a result, several students took turns rolling dice while others tabulated how often each sum had been rolled. After a few turns, one student announced that he had a better way of organizing the data. In essence, he created the concept of a single-dimensioned array on the blackboard. By utilizing the concrete element

of the dice and paper tally, the students were able to generalize their prior knowledge into an application level resulting in a "better" solution. The project instructor supplied the new knowledge concerning the coding of single-dimensioned arrays, but the difficult and often avoided concept had been realized by the students on their own. The knowledge had become meaningful in a manner that was both organic and natural because it had significant analogic connections to the student's prior knowledge base. In subsequent projects, the students demonstrated the shift from a "remember" level to an "application" level by finding additional ways to utilize this concept in new and useful ways. The "process stressing" concept was seen as a central efficacious factor in this type of modification in the learner's behavior. By developing a sense for the "process of learning" through the consistent repetition of the steps of the process, the students internalized a logical architecture providing a systematic approach to problem solving. The absence of this cognitive structure was a modality in the subject population prior to the pilot project's inception and noticeably diminished by the project's end according to the classroom teacher reports.

Perhaps the most significant benefits of the pilot project lay in the area of the carry-over skills developed. Prior to the Spring term in which the pilot project was conducted, a traditional study skills class had been taught. When the format of the course changed to "computer programming" and the venue moved to the computer facility, the students understandably wanted an explanation. With their usual frankness, they asked the project teacher, "How was writing a computer program going to help their poor math grade?" Intentionally, the teacher deferred the question until later. As the students began to realize that a BASIC program was itself secondary to the process by which it was created, the question was raised again, this time by the instructor. It was pointed out that, for example, the effective use of a program editor was noting more than the learning of the correct sequence of steps. The analogy could then be made to solving a word problem. By analyzing the problem, the student could discover the known facts. By asking what was unknown, the student could determine what was missing. By organizing the known data and listing the relationships apparent, the student could find a way to the solution. The common weakness prior to the pilot study was the inability to structure an organized approach to a problem of this nature. With the experience gained in breaking down problems for solution on the computer, the students were able to overcome a feeling of helplessness in the face of what had previously seemed to be unsolvable problems in a broad range of academic pursuits. Problems became a matter addressable by planning, organization and sequencing rather than objects which were "too big to swallow whole."

At the same time, a glossary of terms was provided for analogic application to areas outside of programming. The "causes of the Civil War", the "battles of the Civil War", and the "contributory effects of the Civil War to the civil rights movement", all became "modules" in a larger "program". Thus the relationships between these groups of similar factors became clearer to the students and these elements of new knowledge could then be made meaningful by incorporation within a framework of the existing knowledge base.

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Frances Midkiff, Ed.D.

Enhancing Creativity Through New Technology

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"Computers in my classroom—no way. I have enough to do."

"They are just another fad. They'll go away just like any other gimmick."

"What can computers do that I can't do better?"

"Who needs another workbook even if it is electric?"

"Won't children become antisocial if they spend too much time with computers?"

These statements exemplify comments from teachers not too many years ago. They reflect concern for child development, what constitutes worthwhile learning experiences, and even teachers' fear that their roles would be usurped or drastically changed. Although some of these questions still bother educators, gradually they have to realize that computers are not just a passing fad, but a technological innovation that is demanding and getting sweeping changes in the way students learn and the way teachers prepare the environment for learning.

Statistics show that the use of computers in the classroom has increased steadily from 1974. This increase has come about largely through lower prices for hardware and software, increased availability of educational software, and parental and community pressure to put computers in the schools.

Implementation of large numbers of educational programs for teachers has created enthusiastic "embracers" of this new technology who see the computer as an innovation which can do much to assist in performance of classroom tasks. A growing number of negative comments have been replaced with statements that support computers as highly motivating devices which stimulate students to greater achievement and result in better opinions of themselves as students.

Few teachers who have computers in their classroom need convincing that they can make important contributions to education in a number of significant ways. The concern of most educators now, according to Boyer (1984), President of the Carnegie Foundation for the Advancement of Teaching, is how to blend what is best in traditional education with what is innovative in technology. Concern is less with learning how to operate the computer and more in using the computer for improving learning, less in becoming programmers and more interested in finding and using what is already available that fits particular needs.

There is a growing dissatisfaction with programs which do little that workbooks cannot do cheaper and with less bother. Boyer states:

> . . . all too much of today's computer instructional material resembles a book with blank pages. The technology is available—and increasingly affordable—but educational content that makes the investment worthwhile for schools is largely lacking. (p. 81-82).

Desire for better use of the computer has resulted in a growing interest in the computer as a means for "creative computing", that is an expansion of the computer beyond the level of responding to pre-programmed questions.

Creativity and the Computer

Often misunderstood and misused by educators in their attempt to understand and to implement strategies for utilizing computers with children is the word "creative." Familiar to most of us are the definitions of creativity as either a process or a product.

Advocates of the "product" definition view creativity as a finished product. Emphasis is placed primarily upon the use of the computer to teach a concept or to give a response that has been already identified and programmed. Creativity is seen primarily as a program which is innovative and, therefore, uses novel approaches to help the student arrive at predetermined answers. While

many of these educational programs demand unusual solutions to problems, and can act to stimulate thinking, they don't, as a rule, allow the child to produce anything original. The solution to the problem of how to leave Pirate's Island, for example, has already been determined by the programmer. It is up to the child to figure out what that solution is. In order to do this, the child's thinking must closely approximate the thinking of the programmer. As answers are sought, behavior is chiefly trial and error until a strategy begins to develop. The child's own creative solution to the problem is often met with a sarcastic remark from the computer itself.

Many educational programs, though sometimes highly creative in themselves in that they appeal to the imagination, make good use of graphics and sound, and contain elements of chance, places emphasis less on the child as a producer and more on the demanding of specific information. In many programs, the creative aspects of the program serve as motivating devices and not a means to provide a creative stimulus. In such programs, the real creativity lies with the programmer rather than the user.

Those who view creativity as a process and, thereby, a thinking skill, emphasize involvement of the student and what is happening to him mentally as he strives to solve a problem of any kind—no matter what it is.

Torrance (1965) has defined creativity as sensing gaps in information, forming hypotheses regarding these deficiencies, testing and possibly retesting hunches, and communicating the results (p. 8).

Such a definition does not preclude a finished product. In all likelihood, the result of this activity will be a product, either visual, as in computer art or in a less tangible form such as an idea or new strategy for solving a problem. The prime interest, however, is not on the outcome but what is occurring prior to it. Many children and adults do not know what the result will be like until they have gone through a process of exploration and experimentation with a number of ideas. This process is one of the major differences between product vs. process definitions of creativity. Torrance's definition suggests that creativity is a thinking skill and, therefore, is governed by mental manipulation of ideas. The logical outcome of which can be unique to the individual and hence considered a product.

Laird (1984) states, ". . . creativity is a thinking skill that children can be taught, a skill that will be useful to them all their lives" (p. 70). She says that, ". . . by giving children the opportunity to explore their own potential for creativity, we give them lasting knowledge of how to use their minds creatively." Creativity, then, requires that each student develop his own talent rather than utilizing the thought processes of others.

Children who are accustomed to using dittos and answering questions with one right answer find it difficult to think creatively. The creation of something unusual out of the ordinary is an important component of creative computing. It necessitates the child's interaction with the computer in a playful as well as purposeful way. Psychologists have found that the creative person is one who mentally moves ideas around. He is able to see multiple solutions to problems, some of which are practical and others which are just plain "weird." Could the inventer of Pac Man ever imagine in his wildest dream that a little circle with a hole cut out would enbrace a whole generation of young people and adults alike. Circles, as a rule, do not go around eating other circles. Yet, this game through its novelty, challenge, and imagination has caught the attention of millions of people. D'Ignazio (1984) states in regard to process vs. product

> The computer's greatest value as a learning tool comes when it mixes process and product, when it blends the technical and scientific with the artistic, and when it frees us of inhibitions and taps our imagination, yet still challenges us to acquire more skill and do better (p. 77).

Creative computing can bring the "What if . . ." back to learning. Something dittos seem to find impossible to do.

Creative Computing

What then is creative computing? Creative computing engages the user actively in approaches that are personal and novel and which arise from needs that are unique to the individual. It makes use of existing technology to accomplish its goals. Key components are active involvement, establishing a creative environment, and the use of tools that rid the user of the drudgery of "re-inventing the wheel."

Involvement

Teachers who misunderstand the process inherent in creative computing often accept any kind of involvement as creative. It is a mistake to believe that just putting someone in front of a computer results in creativity. Yet, creative interaction is often used as justification for having a computer in the classroom in the first place.

An analysis of software programs for their potential as a source for creative development shows that many of them have minimal involvement of the student other than selecting the right button or typing in the right answer. Educators are beginning to realize what early pioneers discovered years ago—personal involvement does not mean pushing the right button or key, but giving children the opportunity to use computers in ways that they can structure their own learning.

D'Ignazio (1984) borrowing upon Papert's term "micro worlds," that is "miniature worlds inside the computer that children could create themselves," underlines the importance of fantasy, imagination, charm, and humor in software designed for children. When children are allowed to create for themselves, they incorporate these characteristics into their own work.

According to Piaget, when a child acts upon objects and interacts with people, he is obtaining knowledge which is used to form a personal view of the world. The child's cognitive structure is unique and obtained over a period of time. It is acquired after many opportunities to manipulate, make mistakes, and test findings. Dewey proposed that learning should be active and that children should use their knowledge in relevant ways. When a child creatively uses the computer, he learns something about learning. He learns to experiment with a number of potential solutions and to withhold judgment until he is satisfied with his endeavor. Because creativity is concerned with decision making, devising alternative responses to situations, and employing problem solving strategies in addition to active involvement, the child is free to make responses that are original and personally satisfying. Creativity does not just happen. It occurs when the conditons supporting it are there.

Frances Midkiff . . .

The Creative Environment

Researchers have identified the kind of environment needed to promote creative activity. Successful ones have teachers who believe that creativity can be developed and carefully plan to insure that it does. It is an environment where there is activity and things happen. There is acceptance and stimulation. Playful manipulation of ideas is encouraged and opportunities for exploration provided. Barriers to creativity such as criticism and "pat" answers are discouraged. Time is permitted for reflection and revision. Teachers themselves know the potential for the use of creative tools and use and enjoy new devices and programs with the children. They do not abdicate their responsibilities to the computer but use it to enhance their teaching. They are engaged in an active process of finding, using, and evaluating materials—just as they do with any other media.

Children are stimulated to create for themselves and others. Both their ideas and their failures are accepted and they are encouraged to learn from both. They are shown how to use creative devices and their questions are treated with respect. Recognition is given to different uses of the materials, through provision of those which have differing levels of ability and interest. However, just providing a stimulating acceptable environment is not enough for a truly creative, computer environment. Tools are needed which provide technical assistance for maximum creative output.

During the past five years, there has emerged many useful innovations to accompany the computer. These devices hold great promise for providing opportunities for creating in the classroom.

Creative Tools

What are some of the computer technological innovations that can lead children to discover creativity within themselves?

A tool is an instrument for improving work performance. Its effectiveness is determined largely by the user, the job to be performed, and the time allocated for the task. It allows work to be done in a way that is more economical in time and effort.

Unlike any other tool that has ever existed, the computer not only is a worksaver but a way of extending thoughts and ideas in ways that were never dreamed of before. The computer is probably one of the most creative tools ever devised, however, it does not create anything in and of itself. The creating is done by operators or programmers who generate the ideas. The computer merely simplifies the visualization and production of them.

Until recently, unless you were a skilled programmer, most users of personal computers were limited to only basic use of the computer; that is, writing simple programs and using software designed by someone else. As far as designing imaginative, innovative, animated programs that were a visual delight, it was and still is beyond the capabilities of large numbers of interested computer users. The graphics alone, until a few years ago, were defeating. The enormous amount of time needed to plot them or to generate them through string graphics was more than interest or time permitted.

The past few years have seen a proliferation of devices and programs which give the ordinary user power that was formerly limited to skilled programmers. Three major categories of adjunct devices and specialized programs have emerged which are available for most computers and which increase the computer's potential as a creative tool. They are loosely termed hardware, software, and firmware as a simplistic system for discussion.

Hardware are electronic or mechanical devices which are attached to the computer and are usually known as peripherals. Easily recognizable ones are printers, disk systems, and tape recorders. Not so well known are plug in speech synthesizers, light pens, and musical keyboards. Other types of hardware include devices that assist in generating graphics. Among these are the Power Pad, Koala Pad, and X-16 Pad. Programs accompany these devices which make them useful in generating graphics, saving them, and calling them up later for insertion in another program.

Other software programs are useful in producing sound, speech, graphics, or music. These programs perform independently of adjunct devices and need only the computer.

A third category of devices is that of "firmware" which is a cartridge that can be inserted into the computer. The cartridge has the advantage of its own memory system and is therefore able to be used on computers with small memories. It has an additional advantage in being easy to load and use. However, modifications are limited and in some instances programs cannot be stored or printed.

Language Extensions

A language extension is either a program disk or tape which can be loaded into the computer's memory or a cartridge which contains a program and is plugged into the cartridge port of a computer. It contains additional commands which can be used directly to accomplish tasks either not available in the built-in language of the computer or which would be extremely difficult to do. Typical examples include the Extended Basic Cartridge for the Texas Instrument, the Super Expander Cartridge for the VIC 20 or Commodore 64, and the Cartridge Basic for the IBM. Microsoft Basic is available on disk for the Atari computer. Applesoft is now standard for the Apple computer, but was originally an optional language.

Super Expander is primarily designed to add color, graphics and sound commands. It also slightly increases the available memory of the VIC 20. For the classroom teacher, programs can allow children to draw circles, fill in an area with a color, draw lines, and add sounds. By using the command "draw", a line is drawn between two points designated on the screen. This would take several lines of programming on the expanded computer. The "sound" command sets the tones and the volume all at once, making it much easier to provide sound routines. The music writing mode lets you play notes directly by typing on the keyboard and has the advantage of creating music by using the Print statement in Basic Programs and makes writing chords easier. It can allow the music to play while the program runs. It is designed primarily for playing music rather than sound effects.

The Extended Basic Cartridge has a mind-blowing number of capabilities. This cartridge is a powerful, high-level programming language that expands the capability of the TI computer. In addition to more than 40 additional commands, statements, functions, and subprograms, speed and efficiency, this program has a sprite capability. Sprites are characters generated that move independently of the rest of the program. Extended Basic allows programs to be merged and text to be placed on the screen with graphics. The use of the

voice synthesize is another feature of this program.

Simons' Basic for the Commodore 64 was developed by a 16-year-old boy from England. It has over 100 commands on a cartridge. The cartridge has programming aids such as automatic line numbers, renumbering programs, merge subroutines, and many more commands and serves to make writing, editing, and debugging programs easier. The graphics section includes drawing, painting, and color in high resolution.

Although language extended programs are useful in that they shorten programming time and enable the user to do advanced techniques easily; they also have some limitations. The prime one is that programs are not transferable to a machine not equipped with the extended language. A second deficiency of cartridge based extensions is that they occupy the cartridge port and other cartridges cannot be used simultaneously. Disk based languages must be loaded into the memory of the computer and hence reduce considerably the amount of memory available for programming use.

Graphics Generation

An area which has frustrated teachers and students has been producing pictorial representations with the computer. Previously, only those people who were skilled programmers and who had huge blocks of time were capable of generating graphics. Therefore, classroom programs designed by teachers were usually limited to text and only the simplest visual representations.

Several new innovations show promise for not only making programs more interesting for the user, but which also allow the teacher and student to create for themselves.

In addition to language extender programs, which often have commands which will allow graphics to be generated, drawing programs, joy sticks, light pens, and graphics tablets have appeared on the market which make pictures easier and quicker.

Using a graphics tablet such as the Koala-Pad, Power-Pad, or the X-Pad, even young children can create their own drawings, select color for both background and for the drawing itself, and to select the width of the line. The Koala-Pad is a tablet device which connects to the computer. Using a drawing pencil or the fingertip, the user can produce drawings. The Koala/Painter, an especially designed program for use with the Koala-Pad, has a number of options. One of the most important features of this program is that created pictures can be saved and even merged with text so that children can generate their own stories. Even a pre-schooler can dictate stories in BASIC which the teacher or aide can type. Older children can do their own. Older children can also utilize Word Processing software which, merged with drawing programs, can lead to high levels of creative output.

A limitation of the program is that the user must look at the screen to see what is being drawn. This is difficult at first, but with practice can be mastered. The Koala/Painter has features such as "Fill" program which places color where the cursor is put. A menu provides other drawing options such as magnify, circle, and point. Some of the color options appear to give texture to the art work.

Another tool which can be utilized to produce art is the light pen. The light pen is an attachment to the computer in the shape of a pen which allows it to be used as a drawing instrument. When held against the screen, it evokes light. It has the advantage that the user can see what he is drawing.

The Gibson Light Pen package is a set of graphics programming language and three software packages. The package includes PenPainter for drawing, PenAnimator for animation, and PenMusic for music composition. By using the light pen, it is possible to set, edit, and play back notes on a musical staff. This pen is compatable with the Commodore 64, Atari, Apple II family, IBM's PC and PCjr. Pop-down menus allow a list of colors to appear with just a touch to the word "color." The user does not have to remember which command or symbol calls a specific color. The program also permits the user to change his mind and undo a part of his program.

Educate Light Pen plugs into the joystick port of the Commodore 64 or VIC 20. Software programs include a hi-resolution drawing program, a disk utility, a music program, and a game. There are sixteen colors in the 64 version and the user can erase individual lines or clear the whole screen. A limitation of this package is that after creating the drawing, the program cannot be saved.

Peripheral Vision is another software package which uses the Educate Light Pen. It offers a choice of six brush stroke widths, fifteen colors, and a drawing command. When the drawing is completed, it can be saved on disk or the printer.

The use of creative tools to generate graphics provides children, even young ones, with opportunities to become involved with the computer in ways that are both unique and personally satisfying. A child with paper and drawing materials is limited in what he can produce. Once he commits himself to paper, he is restricted to what he has produced. A computer generated piece of art has the advantage of "change." Most of the better programs allow the child to re-do any part of the picture where there is dissatisfaction.

Research in children's art has shown that children go through distinct stages in their art development (Lowenfeld, 1970). When they are given materials for the first time, they are curious as to what they can do with them. As they explore the use of the media, they manipulate drawing materials in ways that are unique to their ages and experiences. Their unrecognizable scribbling gradually changes to recognizable forms. As this happens, language often accompanies the process. Children name their pictures, discuss them, and create stories that are often more elaborate than their forms on paper. In addition, it has been noted that children repeat those actions which are pleasurable to them. These findings related to children's art have important significance for educators who wish to do more with their children and computers. Observations of children using drawing computer programs clearly show that children go through stages similar to those of children creating with traditional art materials, stages which can be identified as sensori-motor (manipulate), presymbolic (in search) of a symbol), and symbolic (visual representation). The manipulative stage is an important one and may last a long time for many children who must learn the mechanics for making the forms they wish to produce. Children must gain control of the media in order to execute a deliberate piece of work. Many drawing programs allow children to master the technical parts easily and fairly quickly.

In addition to creating works of art, the computer stimulates children to become involved creatively who might not choose to do so ordinarily. Observations of pre-school children by the

author showed that when given the opportunity to choose whether to work with art or other play materials, some children never chose art. Many of these children were boys who elected to use blocks or other construction toys. These same children were excited about the use of the computer and soon mastered the mechanical manipulations necessary to produce pictures that they were very excited about. When they were not using the computer, their experiences were reflected in their other play. For example, some of the children began drawing with crayons so that they could remember what they wished to do when their turns came again. It was sometimes difficult to tell whether some of the themes in the block corner originated with the computer or in the block corner and then to the computer. However, it was noted that the computer was playing a significant role in how the children organized their play.

One of the problems with using some of the new software devices is that pictures cannot be saved and/or printed. Computer magazines provide short programs to overcome these deficiencies through programs which are used in combination with other software. Peele (1984) has a procedure using the Super Expander Cartridge (VIC and Commodore 64) and his program called "Hi-Res Screen Dump." Written in machine language, this program is designed to transfer the bit information from screen memory to the printer. For the program to operate correctly, the Hi-Res program must be loaded and run before the program which creates the Hi-Res image.

Programs in BASIC can be saved using the same procedures for saving any program. This means that programs that contain commands such as "draw" in the Super Expander can be treated as any other program and saved. Machine language programs are more difficult as the merging of Assembly and Basic Language is not usually allowed.

Generating Sprites

The use of Sprites is another way for children to use graphics in novel and interesting ways. Sprites are characters which are generated and when called up, can move. Most of the programs to produce Sprites are done through character generators which write a program to create characters. The program produced a grid on the screen. Places (Pixels-picture elements) in the grid are lighted till a picture is made. Arrow keys, specially designated key, or joysticks are used to help move the cursor across the screen to the desired spot. Often the only command needed is 'Enter'.

Numerous programs exist to generate Sprites for the Atari, the Commodore 64, and the Texas Instrument (TI). Moving Sprites are a feature available in TI Extended Basic. Even beginning programmers can call up the Sprites through built-in sub-programs. Commands allow them to be called, defined, magnified, set in motion, and change character definition (Hapman, 1983). Subroutines allow all or parts of the Sprite to move either together or independently.

Used in combination with music programs, children can write music to illustrate movement on the screen. They can create stories which use Sprites to lend excitement to the story. They can design learning games for themselves and for their classmates.

Other limitations with graphics programs include limitations to the screen. Horizontal, vertical, and diagonal lines are a function of the screen. Students must get used to not being able to use the entire area. Although young children are sometimes bewildered and frustrated by this, older children soon learn to operate within the available space.

Another problem occurs in some programs if the line goes beyond the screen. The cursor may wrap around and reappear on the other side causing some confusing and mistakes in drawing. Many programs cannot draw curved lines. Control of the cursor is sometimes difficult. Care must be taken in some of the simple programs when drawing over a line as the cursor may be hidden when the line is drawn. The more sophisticated programs have a flashing cursor. Children soon get used to this and become very innovative in creating pictures that are all lines and angles. Some programs have built-in circle generators which can be called up.

Children also tend to compensate by using color. One of the things computer art programs do well is to encourage color usage. Drawings tend to reflect attention to color background, change of color in lines, and the experimentation with many colors. The "Fill" and "Paint" commands are popular with both young and older children. Because colors can be tried, discarded, and replaced by new ones, children are prone to stay longer with one picture.

There is a possibility that with increased use of computer art, children may start to pay attention earlier to the mechanical aspects of art; that is, more attention to composition, color space, and background. The effect that this may have on their drawings is worthy of observation and study.

It has been noted by the author that the computer can lead to drawing and art work beyond the computer. Children working with adventure games draw pictures that reflect some of the features of these programs. Many of these pictures have more detail than is usually expected from young children's drawings. Despite the contention that working with the computer will turn children into "loners", the author has observed that when more than one is working with the computer, they discuss, analyze, and encourage experimentation and discovery with their art work.

Generating Computer Sound, Music, and Speech

Computer sound generation received very little attention in the design of early personal computers. For example, the TRS-80 had no built-in sound capability and the sound capability of the Apple was quite limited. Each new generation of computers has incorporated increasingly more sophisticated sound. The Commodore 64 has a three channel sound system built in. It was necessary for early programmers to resort to machine language programming to generate even simple sounds.

Within the last two years, the affordability of devices for sound, speech, and music has become a reality for computer users and the classroom.

Voice synthesizer packages are becoming available which give the computer the ability to talk and can be used fairly easily. COMvoice is a package containing a cartridge, speaker and cord, and an instruction manual. It is available for the VIC-20 and the Commodore 64. The cartridge plugs in the computer and the speakers plug into the cartridge. The program uses the BASIC command "Speak" instead of "Print." The words to be spoken are typed into the computer using double quotation marks. This package pronounces 95 percent of English words correctly. Words which are not pronounced exactly can be made to

do so by spelling them the way they sound. Inflection can also be added to stress words and to ask questions so that the sound is closer to the human voice (Heimarck, 1984).

Some extended language programs have sound, voice, and music possibilities. TI Extended Basic has speech capabilities, however, vocabulary is limited. The TI Terminal Emulator cartridge allows an unlimited number of words which can be pronounced accurately. Using this program, the user can generate speech through a few simple commands. With this system, one programmer has his computer speaking Burmese.

These packages have rid the user of the need to learn an elaborate phonetic code which has to, in turn, translate typed in words into numbers and symbols recognized by the computer.

Although the voices are typically computer voices and must be accepted as such, children can learn to use the programs fairly easily if they can spell the words. Teachers can assist them by typing dictated stories which can be added to their art work. One innovative pre-school teacher had the computer tell the children that it was clean-up time. The novelty of it produced a clean room in record time.

Programs are now being developed which will improve voice quality. Commodore 64 is developing a program with chips which will have masculine, feminine, and children's voices.

Music generating programs are another innovative tool which children respond to with enthusiasm. Music generating programs are available commercially for almost every computer and regularly appear in the computer magazines. They permit children to compose their own melodies and to play the computer keyboard as you would a piano. One program, available from the TI user's group, allows children to not only play the computer as an instrument but gives them a choice of type of instrument. They can choose whether it will be an organ, a harpsichord, or will play harmony. An additional feature of the program is that on the screen are numbers which correspond to keys on the computer, middle C being key number 3. Children can read the numbers and play simple songs.

As the child becomes sensitized to problems in composing his own melodies, he is stimulated to find solutions for solving them. He becomes an experimenter or an explorer, finding satisfaction in developing potential solutions. A young child with a music program finds enjoyment in sounds and soon moves on to repeating patterns. He may try out several possibilities—testing each one, and discarding or keeping them according to his own inclination. He may spend several days refining his work or discard it completely to begin work on a new one. Each new composition is approached from a higher level of knowledge and skill than the previous one, due to the information obtained through previous processes. His ability to recognize and overcome problems grows as he formulates questions and becomes self-confident in his ability to solve them. Children engaged in creative computing tend to develop confidence in their learning ability. They are highly motivated because they are in control of their own learning.

Conclusion

New technology has helped to emphasize the use of the computer as a tool which can serve to stimulate creative output from the user. Utilities which can be used relatively easily have reduced the drudgery of spending hours in programming. Focus has shifted to creating the work itself.

Creative computing has as its underlying premise, that each person can develop his potential for creative thinking and, when he does, he reaches higher levels of learning. Creative tools can facilitate novel uses of the computer by everyone, not just the computer "wizard". Learning for many children can be a tremendous leap forward as they are motivated to create rather than to learn isolated facts.

Learning for each student will not necessarily be the same. He will be learning how to learn, how to find out, and how to process information and will use ways which are different from those now. Creative computing requires experimentation, discovery, trial and error, and learning from mistakes. Children need to question and to plan. This type of learning environment may be a challenge to teachers who are used to more traditional modes of instruction. It may be a threat to those who have been trained in more traditional models of instruction. It may be necessary for them to re-think their views on what is significant to learn, teacher-child relationships, and strategies for improving teaching. Possibly, those persons responsible for educational policy must redefine the role of the student. Emphasis may start to be upon the child's involvement in his own learning to a greater extent than at present.

Outside of a nuclear holocaust, technology is not going to disappear—on the contrary, new devices and software are becoming available every day. Getting control of it and encouraging children to use it to expand their horizons is a tremendous challenge for the eighties. One in which all of us have a stake!

If we are to become a nation that controls technology and not be controlled by it, we must produce thinking, creative, people who can make demands upon technological innovations and, at the same time, place limitations. Creative computing holds great promise for helping to develop this type of person. As more tools become available, the possibilities for developing innovative, exciting, learning experiences become a reality for every child and teacher and not just for a fortunate few.

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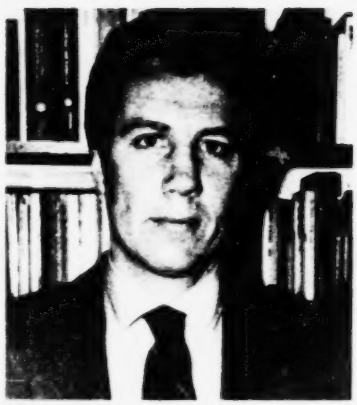
Michael W. Fitzgerald, Ph.D.

Computer Learning Environments and Critical Thinking



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Recently, software designers have begun to exploit the video-game format for educational purposes. Marketers of this hybrid of the classroom and the arcade have hit upon the phrase "learning environment" to describe their product. Also called "discovery tools," such software has received much notice, but it is too early to judge its real educational worth. In fact, our suspicisons should be aroused by the many reviews written by enthusiasts touting them as a panacea for the problem of teaching critical thinking, however we choose to define that skill. On the other hand, an impartial inspection of a representative product may persuade us that something significant is afoot. But where do we start?

Let us take a learning environment in which critical reasoning skills are supposed to be taught which were once thought to be beyond the ken of most adults, much less nine-year olds: *Rocky's Boots* (Robinett). Let me first describe the product and the critical skills it purports to teach before evaluating its particular value and that of learning environments in general.

Rocky's Boots

Described in the *New York Times* as "an electronic Erector set of the mind that leaves the player surprisingly well-grounded in the basic logic concepts underpinning today's computers," (Sandberg-Diment). *Rocky's Boots* focuses on the sometimes mysterious inner workings of computer circuitry. It utilizes the concept of the "gates" which function at the hardwired level of machines and control the computer's computations. The object of the game is to construct working circuits that observe the same logical rules which apply to computers—the rules of Boolean algebra—while playing an arcade-style game. According to Warren Robinett, the game's designer and author (formerly a game programmer at Atari), "*Rocky's Boots* is a good example of a way to make abstract concepts concrete enough for young children. Boolean logic has always been considered to be far too abstract to teach to third-graders. Once I started to design the logic gates, I decided to use colors to display the state of the circuits. That meant I could convey an abstraction like logical truth and falsity in concrete terms of orange fire that flowed through pipes." (Rheingold).

Rocky's Boots introduces the concepts of Boolean algebra in a sequenced set of tutorials which lead up to "Rocky's Challenge," the last stage of the game where the player creates logic machines for tasks that require knowledge of circuit design. The tutorials commence with the basics of cursor movement and proceed through the elements of building machines that use logic gates (including AND gates, OR gates and NOT gates). Players develop their facility at designing machines in "practice rooms." Long before arriving at "Rocky's Challenge" players can be wiring circuits to power machines which make delightful sounds or provide stimulating visual fields. If correctly wired, machines can also be used to trigger a boot which kicks targets, thus scoring points. Rocky the racoon appears on the screen and performs a little jig when enough points have been accumulated. In the last tutorial such circuit components as flipflops, clocks and delays are introduced to provide the "hardware" for more advanced designs.

The Logic of Boolean Algebra

To appreciate Robinett's achievement in *Rocky's Boots* we should review some rudiments of Boolean algebra. Invented in the last century by the English mathematician George Boole, this algebra later became the basis for symbolic logic and sentential calculus. In his major work, *An Investigation of the Laws of Thought on Which Are Founded the Mathematical Theories of Logic and*

Probabilities (1854), Boole set himself this goal:

> The design of the following treatise is to investigate the fundamental laws of those operations of the mind by which reasoning is performed; to give expression to them in the symbolical language of a Calculus, and upon this to establish the science of Logic and construct its method. . . . (Bartee)

Boole's system rests on three basic ideas: (1) the conception of the operation of "elective symbols"; (2) the idea of "laws of thought" which are expressible as rules of operation upon those symbols; and (3) the observation that these rules of operation are the same which would hold in an algebra of the numbers 1 and 0 (Lewis and Langford). The first idea concerns the algebra of classes and has important consequences for the logic of group theory. The second and third notions have direct repercussions for digital computers. When a variable is used in an algebraic formula, it is usually assumed that it may be assigned any numerical value. But the variables used in a Boolean equation have the unique characteristic that they may assume only one of two possible values, either 1 or 0. Furthermore, the equation itself will contain certain logical relationships which may be used to determine its value. These logical relationships may be reduced to a small set of algebraic operations: logical addition, logical multiplication, and complementation. These are expressed respectively by the symbols $+$, $\cdot$ and $'$. If the relation of logical addition obtains between two variables X,Y (each of which can only have the value of 1 or 0), we can define the $+$ symbol by cataloguing all the combinatorial possibilities for $X + Y$, as illustrated in the following table:

$X + Y = Z$
$0 + 0 = 0$
$0 + 1 = 1$
$1 + 0 = 1$
$1 + 1 = 1$

The last entry in the table calls our attention to the fact that the $+$ symbol does not have its usual arithmetic meaning (i.e., "X added to Y equals their sum, Z"), but rather must be understood as "X *or* Y equals Z." This concept may be extended to strings of variables; for example, in the equation $V + W + X + Y = Z$, where V, W, X, and Y each have a value of 1, the result of their logical addition still yields 1.

The relation of logical multiplication may be expressed in a similar table:

$X \cdot Y = Z$
$0 \cdot 0 = 0$
$0 \cdot 1 = 0$
$1 \cdot 0 = 0$
$1 \cdot 1 = 1$

Note that only when X and Y are both 1 is Z equal to 1. This underscores the necessity for recognizing that Boole's algebra is completely interpretable as a system in which the "elective symbols" are 1 and 0. The fundamental law peculiar to this algebra is $X X = X$ (or $X^2 = X$), a law which holds of 1 and 0, and of no other numbers (Lewis and Langford).

Logical addition and logical multiplication are termed binary operations because they define an operation on two variables. There is also a unary operation, called complementation ($'$), which defines an operation on a single variable. It too may be defined in a table:

X	X′
0	1
1	0

This operation is understood by logicians as negation or denial. Thus the complement of a value is its inverse.

There are several other important operations in Boolean algebra, but they need not detain us. The operations of logical addition (which we may now call the OR function), logical multiplication (the AND function) and complementation (the NOT function) suffice to introduce the application of Boole's algebra to digital computers.

Boolean Algebra and Computer Circuitry

Boolean algebra was recognized as a possible solution to problems which had arisen in the design of relay switching circuits in 1938 by Claude Shannon, then at the department of electrical engineering at the Massachusetts Institute of Technology. In his Master's thesis, "A Symbolic Analysis of Relay and Switching Circuits," Shannon devised a method for representing circuits of switches and relays by a set of mathematical expressions manipulable by a calculus based on Boolean algebra. The techniques which were subsequently developed for the design of relay circuits almost universally adopted Shannon's methods, and modern electronic circuitry continues to employ them. The internal operations of a computer at the level of the printed circuit are thus describable in terms of Boole's algebra (Bartee).

The operations of logical addition ($+$) and logical multiplication ($\cdot$) are electronically manifested in two types of circuits respectively called OR gates and AND gates. A gate is nothing more than an electronic switch which operates on one or more input signals to produce an output signal. Gates control the flow of bits (binary digits) through a computer. They are analogous to the switches found on a railroad system. By opening and closing various switches, a train dispatcher can route a particular locomotive to a specified destination. In a computer, networks of gates can be used to send particular bits of information to various locations in the machine's memory (Benrey).

The operation of a gate may be regulated by more than one control terminal, even though each gate has only one output terminal. Thus complex gating systems can be constructed by wiring multiple control terminals, although few computer applications require more than five or six.

When electronic signals (representing bits) are fed into control terminals, the gates are either opened or closed according to the particular logic of the gate. It is here that Boole reappears. The output is registered in terms of a bit, which is encoded as 0 or 1, and which we can understand, in terms of the action of the gate, as either opened or closed. Most importantly, the output is functionally related to the values of the input bits. AND gates and OR gates differ in the values of the input bits that will open or close them. As we can infer from Boole's analysis of logical multiplication, an AND gate will generate an output of 1 only if *all* the input bits are 1's. An OR gate, on the other hand, will produce a 1 output if *any* of the input bits equals 1—just as we find in the Boolean conception of logical addition.

The operation of complementation can be realized through the use of an inverter, sometimes also called a NOT gate. Since complementation is a unary operation, an inverter requires only one input terminal and one output terminal. A NOT gate simply complements or inverts the value of the input bit. Thus, it the input bit is 0, the output will be 1; if the input is 1, the output will be 0.

Since it is often important that one bit reach a designated circuit before another bit, a delay circuit can be used to retard the movement of the second bit. A delay thus insures that bits arrive at circuits in the proper order. The input signal appears at the output in exactly the same form in which it entered the delay, but slowed by a duration fixed by the circuit.

Any list of elementary circuits must also include the bistable circuit, or switch. A switch has two states: "on" and "off." One of the two stable states is assigned the value 1, the other 0. Such circuits are often used to represent the bits within the calculating sections of a computer; when grouped in series they can be used to represent whole binary numbers. These switches are also called "flipflops," the name they carry in *Rocky's Boots*.

So far we have five elementary circuit "building blocks": the AND gate, the OR gate, the NOT gate, the delay and the flipflop. These are the basic elements of *Rocky's Boots* as well. They are used to construct machines whose circuitry simulates the functioning of computers, as the games in "Rocky's Challenge" demonstrate. But what, if anything, does *Rocky's Boots* have to do with critical thinking?

Critical Thinking Skills

What do we mean by "critical thinking skills"? Educators have not established a consenus regarding such skills. But it seems reasonable to assert that critical thinking and problem solving have something in common. Problem solving requires the devising of means which will accomplish a given task. The more complex the task, the greater the difficulty in discovering the means for its solution. More specifically, problem solving demands (1) the identification of relevant data within the ambit of the task, (2) the conjecture of possible solutions, and (3) the testing of these solutions. The entire process is virtually identical with the steps found in hypothetical explanation. For example, take the task of deciphering a Mayan hieroglyphic inscription. First, the field of signs must be identified and differentiated. Second, hypotheses must be advanced as to the meaning of these signs and their rules of operation. Third, the hypotheses must be tested to see whether they yield the desired result: do they unlock the meaning of the Mayan inscription?

The reasoning just described can also be viewed as requiring specific intellectual abilities which correspond to each step of the tripartite problem solving operation. First, we break down the problem into its elements (analysis). Second, we construct a possible solution by reintegrating these elements or by introducing new elements (synthesis). Finally, we test the solution thus tendered for its efficacy (evaluation).

These three abilities—analysis, synthesis and evaluation—thus might justifiably find a place in an inventory of critical thinking skills. Bloom includes them in the *Taxonomy of Educational Objectives* for the cognitive domain, where they crown the hierarchy of intellectual skills. How are they described within this taxonomy?

Analysis entails the resolution of a problem into its constituent elements or parts. Analytical thinking establishes the logical relationships which exist among these elements. In this way, analysis clarifies the arrangement and basis of those parts of the problem which will figure in a solution, along with an explicitation of any unstated assumptions contained in the problem or required by a solution (Bloom).

Synthesis concerns the composition of these parts or elements in the solution which emerges to the problem. It is significant that the solution integrates its elements into a whole whose organization was not supplied by the analytic resolution of the problem. Synthetic reasoning frames solutions according to abstract relations such as those necessitated by classification or explanation, It also operates in the deduction of propositions and relations from a set of basic propositions or symbolic representations.

At the apex of Bloom's classification of intellectual skills we find evaluation, which is characterized as the ability to judge the value of materials or methods for given purposes. At this level, standards of appraisal are required both for the evaluation of internal evidence (such as logical consistency and accuracy) and for judging external criteria (such as the worth of alternative theories or explanations).

Rocky's Boots and Critical Thinking

Assuming that these three skills can be used as a starting point for the characterization of critical thinking, how does *Rocky's Boots* encourage their development in the young mind? Certainly the logical dimensions of analysis, synthesis and evaluation find application at the higher levels of "Rocky's Challenge." For example, the game called "Green Diamonds or Blue Triangles" demands that the player analyze the elements involved in kicking EITHER shapes which are green AND diamonds OR shapes which are blue AND triangular, OR both. This is what is yielded by an analysis of the propositional logic of the object of the game. The player must proceed to devise a system of circuits which will produce this result, that is, he or she must bring together in the proper order the gates that will be activated by green diamonds or blue triangles or both green diamonds and blue triangles.

Finally, the player must evaluate the success of his or her solution. Has the object been realized? Are there more efficient ways of wiring the circuitry and getting the same result? Have any glitches occurred? Can a machine be built which will kick green diamonds or blue triangles but **not** both?

So we must concede that *Rocky's Boots* requires the critical skills enumerated by Bloom. But what is it about the game that so facilitates their acquisition? I believe that the answer lies in the gaming format itself. Games like *Rocky's Boots* utilize an operational or process approach to learning. They encourage the player to test or apply immediately the skills presented in the tutorials. They dispense with long-winded theoretical explanations of how circuits and gates work. To use Piaget's distinction, they teach by instantiating knowledge in **procedures** rather than in **propositions**.

Finally, it should be noted that the catalyst in the acquisition—i.e., operationalizing—of these reasoning skills is **play**. The happy marriage of the arcade-game format with a stimulating intellectual challenge might well serve as a paradigm for future learning environments. Play motivates most of us to continue exploring and experimenting, and play rewards us with certain intangible satisfactions when we succeed. Most of all, play is fun. If there is a revolution underway in our schools, it is the increasing demand that learning be an enjoyable enterprise. If that is the case, then *Rocky's Boots* and learning environments like it are in the vanguard of the movement.

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Lynne F. Mann, Ed.D.

Manipulatives and the Microcomputer: Have you got a MATCH?

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Optimal learning experiences for the pre-operational child are those experiences which involve the exploration and manipulation of concrete objects. It is through the manipulation and exploration that the young child constructs his own knowledge. Although not a "concrete manipulative", a computer can become a tool for learning.

Matching Learning Styles

In order for microcomputer use to **match** the learning styles and learning needs of the young child, the teacher, and parent must be aware of their respective roles in creating an optimal learning environment for the young child. Several factors are critical in creating the **MATCH** between the child, microcomputers software, and manipulatives. These factors include the recognition of the developmental needs of the young child, responsible and critical examination of selected software and suggestions of appropriate concrete manipulatives for use with selected software.

In a discussion of 'the problem of the match', J. McVicker Hunt (1966) presents the idea that several considerations are necessary when designing optimal learning experiences for young children. Previous experiences, maturation, and interactions are three essential elements to consider. Basically, Hunt explains that before designing experiences that will optimize learning, the child's level of maturation or development must be known. He also states that it is helpful to know something about the child's previous experiences. When these are known, it will be easier to create learning experiences for the child in which he can capitalize on what he is able to do and combine that with what he already knows. 'The problem of the match' comes to be no problem at all when activities are selected that are at an appropriate level which is consistent with the child's development/maturation and which build upon his previous experiences.

The developmental needs of the child from 4 to about 7 are fairly consistent across children. The pre-operational child is quite capable of thinking about things as long as those things are in front of him or accessible to him. As he gets older, he will become more able to think about things that are represented by pictures and finally with symbols and/or words.

Construction of Knowledge

The belief of many educators of young children is consistent with the idea that the young child constructs his own knowledge. In an early childhood setting it is necesasary to have a variety of objects that can be explored and manipulated, and it is necessary to consider instructional methods that are consistent with the nature of learning styles of young children. The following levels of instruction are consistent with learning at all developmental levels. However, for the pre-operational child, all experiences must include concrete objects.

The first step a teacher would take in presenting a new concept to her children would be to informally introduce the concept to them. For example, if the concept of color was to be taught to children, the teacher would have many instances of "color" in the class, blocks, paper, crayons, markers, fruit, etc. At this informal level, the teacher would merely use color words in descriptions or directions with the children. The second level of instruction would be to provide active experiences with the concept. Here the teacher might discuss the colors of the clothing that the children wear to school or of the color of their lunchboxes. The third level of instruction defines the limits of the concept.

(color doesn't tell how many, or color doesn't tell when). The fourth level of instruction is the formal presentation of the concept. Here, the teacher would actually present the color words to the children. After formally presenting the concept, the teacher would provide many opportunities for drill and practice with the concept. Learning centers, matching games and color sorts are a few of these practice materials. Finally, the teacher will provide opportunities for spontaneous use of the new concept. At each level the teacher will evaluate for success and back-up a level or two as necessary. It should be noted that these six levels of instruction vary in duration from step to step. For example, it is expected that drill and practice may require more time for some children than others before spontaneous use occurs. Regardless of the curriculum, area or grade level, these six levels of instruction enhance sound educational practice. For the pre-operational child, concrete manipulatives presented in a manner consistent with sound instructional methods and that match his maturation, experiences, and level of development will facilitate learning.

The Role of Computers

While apparently inconsistent with the previous presentation because they are neither concrete nor manipulative, the microcomputer can be used responsibly and successfully with the pre-operational child. This can be accomplished if conscious effort is made to create a **MATCH** between the child's level of maturation and the charateristics of his learning environment. In order to facilitate the child's development, or construction of knowledge, the teacher will provide many objects which can be manipulated by the child. Consequently, many pre-schools and primary-grade classrooms have several areas in common, (the housekeeping corner, dolls, blocks construction areas, art areas reading corners and water and/or sand play). What will be suggested below is another "area", a "microcomputer-manipulatives-area".

It has been suggested that the microcomputer is an environment unto itself, while this may be true in many instances, the "micro-worlds" created in the "micro-environment" (such as with Logo) may not be concrete enough for the pre-operational child. At best, the images on the screen are at a pictoral level, and in most instances they are symbolic. If it is accepted that the pre-operational child must have manipulatives in order to explore and create his own knowledge, and if it is accepted that the microcomputer itself is not a manipulative object, then the goal is fairly simple. The goal is to create an environment where the microcomputer can become manipulative. More simply, it is necessary to provide concrete manipulatives that the child can use to replicate, explore and manipulate the "micro-worlds" which are found in the computer environment and which are untouchable.

The manipulatives to be included in the "micro" area can range from those that can be found in most early childhood settings such as colored inch cubes, small geometric-shaped blocks and paper and crayon/pencil, to those more specific to selected software. Although many software manufacturers believe that they have anticipated the needs of the young child and that their products meet those needs, in most instances, the teacher/parent must make this critical decision.

Again, the teacher must **MATCH**. This time the **MATCH** involves the maturation of the child, the environment designed to facilitate learning, the level of instruction, ***and*** the software. In this **MATCH**, the software must be consistent with the level of instruction and the "micro" area must exemplify the software, they both must be consistent with the level of child development/maturation and learning mode! For example, ***Facemaker*** (Spinnaker Software, 1982) will be used to provide active experience (level two of instruction) with the concept of "Heads have similar parts". The "micro" area might include such items as a styrofoam ball and face and head parts to be attached, a commercial game that has plastic head parts, scraps of fabric and yarn, a mirror, and paper and crayons or pencils. The child could play with the concrete materials and create a variety of faces and heads. The software could become an exploratory medium for the child as he re-creates his concrete construction on the computer or recreates his computer construction with the concrete materials. (A fairly specific list of suggestions of appropriate software and manipulatives can be found in Tipps, R.S. and Mann, L.F., "Computers for Young Children." *Dimensions*, October, 1984, in press).

If microcomputers are to be used to create optimal learning experiences for young children, they must **MATCH** the child's level of development/maturation, the software chosen must **MATCH** the level of instruction, and the "micro" area must **MATCH** the software, the level of instruction, and the level of child development. Have you got a **MATCH**?

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Cynthia L. Paris, M.S.

Early Computer Experiences: Curriculum Materials and Activities to Precede and Accompany a Child's First Computer Years

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She has been a kindergarten and elementary teacher in public school, teacher/director of a private nursery school and master teacher in the University of Delaware Preschool. She has taught an undergraduate practicum course in "Preschool Curriculum" and developed and taught the course "Computers in Early Childhood Education" at the undergraduate and graduate levels. She was one of the original Coordinators of the Computer Active Preschool Project (CAPP) and has served as master teacher, staff trainer and administrator of the CAPP Summer Computer Camp for Young Children. She has developed computer curriculum materials and activities and has conducted research on peer teaching and helping behavior of children using computers.

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Young children who are successful computer users are comfortable, confident and, to a great extent, independent at the machines. They approach the computer without hesitation. They load and start the computer without checking repeatedly with an adult to be certain they did it "right." They call on a teacher to show what they have done more often than to seek help. In fact, they eagerly share their computer skills with children or adults who need help. And when presented with a new piece of software, or even a different computer, they explore them with aplomb, using what they know of software and computers in general.

How does a young child become a successful computer user? What must a child be able to do or understand before they can use a computer with ease?

Computer Literacy for Young Children

A list of skills and concepts thought to be necessary for successful computer use was compiled from observations of forty-three children between the ages of four and seven who attended the University of Delaware's 1984 Computer Camp for Young Children. Concepts selected defined computer literacy for young children, though only one was necessary for a child's confident use of computers. The skills selected were considered necessary for children to operate a computer correctly, to do so with ease and confidence, and with only as much assistance as a classroom teacher might be expected to give.

Both skills and concepts were included only if at least half of the successful children observed demonstrated these skills after four weeks of instruction.

Developing skills without understanding produces learnings that a child is less likely to apply and build on. For this reason these five computer concepts were included.

- the computer is a machine with strengths and limitations like all others
- children can use computers to draw, play games, record and animate stories, and help them practice academic skills
- adults use computers to help them do their work in the community
- a computer is made up of parts working together to take in information and send out information
- computer hardware and software is made by people and control computers

Computing skills taught to young children should enable them to use a broad selection of the computer's capabilities, and feel in control of the machine while doing so. They should be able to:

- turn the equipment on and off
- load software (in this case, disks)
- locate keys on the keyboard
- use a single keystroke
- match movements of the hand controller to those desired on monitor
- select options from a simple menu, for example, the picture menus
- move between menus to make more complex choices, for example, in word processing software
- use a two-part procedure such as the repeated pattern of "Space Bar-Return" to select features on "Facemaker" (Quinn and Weinstein, 1983)
- begin to plan procedures to achieve specific results, for example, deciding to use all the colors in "Magic Crayon" (Clark, 1983) to draw a rainbow, then adjusting the size of each arch to above another, or make the cursor in "Delta Draw" (Gill, et. al., 1982) form their initials.

Preparation for Computer Use

Preparing children to use computers involves careful attention to these individual skills, and close observation of children as they work at computers to determine what activities and materials should be introduced. Some of the skills and concepts can be developed best when the child is working at a computer, for example, turning it on and off. But many may be, and in some cases, should be accomplished through work with other materials. Some, in fact, could precede the introduction of a computer into the classroom or be used to maintain computer skills and understanding when the computer is assigned to another classroom.

For each concept and skill outlined above, suggested activities were presented. The activities and materials included were developed over the past two years by the staff and students of the University of Delaware's Computer Active Preschool Project and intended as prototypes rather than prescriptions for activities and materials individuals will prepare to match their own goals and their children's capabilities.

Aids to Independent Use of Computers

No matter how carefully children are prepared for computer use, some teacher assistance will be required. But, for a computer to enhance an early childhood program rather than dominate or detract from it, teachers must not feel they are devoting excessive time to supervising children at the computer, and children must not feel dependent on adult help to achieve success.

There are times when close teacher supervision will be required. When a new piece of software is introduced, teachers often need to read cues and directors, explain menu choices and locate special purpose keys that may be new to the children. A child who wishes to save or print her work will most often need a teacher to help her through the procedures. Children using a word processing program also are more dependent on an adult for assistance and encouragement.

But when young children are using familiar software, they can become remarkably independent. Teachers can oversee their computer work from other locations in the classroom, offering help as needed. Children most often required help with recalling the correct loading and start-up procedure, locating necessary keys on the keyboard, and reading a printed menus and directions. To help a child load and start computers without assistance, memory aids such as numbered stickers, or cue cards mentioned previously could be provided.

Keyboard difficulties will not be solved as easily. While keyboard activities and, experience at computer keyboard will eventually lead to mastery, children need to locate necessary keys easily even when first using computers to feel successful (C & C Software's Magic Crayon 1983, for example). Some software manufacturers provide stickers to place on the front of necessary keys with symbols that indicate their function. Some teachers recommend marking necessary keys with colored tape. A mask or frame over the keyboard exposing only necessary keys allows children to use a piece of software easily, but may not help them learn where those keys are found in relating to the rest of the keyboard.

Compensating for the limited reading skills of young children is also possible. Rebus direction cards or menu cards to accompany each piece of software are very effective. If stored with, or attached to the disk cover, children refer to them often, and proceed without waiting for a teacher's help.

Software that focuses on reading or writing skills often requires a great deal of keyboard knowledge. In word processing, or Spinnaker's "The Story Machine", for example, the child is expected to compose sentences, spell or copy the words in those sentences, and locate all the necessary letters on the keyboard to type those sentences. While either the language arts skills or the keyboarding skills alone would prove challenging, together they may become frustrating to a young child. Creating a story with "The Story Machine" can be broken down into more manageable parts if the child first selects the words to compose a sentence, then copies those words onto a nearby court, then directs all his effort to finding the necessary keys to type his sentence.

When first using a word processor to write stories, writing down a basic story on paper with a teacher before coming to the computer, has proven helpful. The child may then concentrate on typing and learning to use the composing options that allow him to amend and elaborate on his story as he wishes.

Activities to Accompany Specific Software

Careful observation of children using computers will help teachers identify sources of children's frustration. Frustration may indicate the need for additional experiences off the computer to help children build necessary skills. Or it may suggest the need to break down or simplify the computer tasks by supplying memory aids, rebus cues or separating tasks.

In computer work, young children are expected to manipulate symbols. Observations guided by knowledge of child development may indicate that some children's frustration is due to the symbolic rather than technological aspect of the task. It must be remembered that the pre-operational child will need many concrete experiences to build a foundation for symbolic tasks Papert (1980) refers to "transitional objects" that provide connections between abstract knowledge and the sensorimotor learning style of the young child. Papert's turtle robot is such an object that allows children to build their own connections between the turtle robot's movements in three-dimensional space and the movements of a cursor on a computer monitor. Concrete objects and motor activities can be used to accompany specific software in much the same way Papert's robot accompanies LOGO graphics. Such materials would

allow a child to move alternately between a concrete version of a task and the symbolic representation on the computer.

For example, children are using drill and practice software to practice addition equations, some will need real objects to count and combine. Colorful and often lively animated "objects" that appear on the monitor for children to count do not provide the same tactile and kinetic feedback as picking up and moving real objects. Providing baskets of real objects to count, or perhaps an abacus provides the concrete experience that the computer does not.

For most software, accompanying materials must be more sophisticated. For example, Bumble Games (Grimm) leads children to locate hidden objects and plot points using coordinates. Experiences hiding, finding and tossing real objects provided children to explore coordinates in space with their bodies. Grids taped onto the floor were used for target games in which children named a column ("Throw it above the "B") or a row ("Throw it across from the 3") or an exact point ("Can you make it land on C,2?). Children hid objects in a sand table that was partitioned like a graph and gave clues to their partner ("Look in A,3") to find them. As their skills increased, children plotted points with push pins on a bulletin board graph and connected them with yarn to make designs.

One must be cautious, however, when providing supplemental experiences to accompany software. Observations of children using this software and knowledge of how children learn may suggest that supplementing a particular piece of software is insufficient and that a piece of software may be better replaced by concrete experience.

Conclusion

If young children are to use computers in ways that will enhance both their learning and their self-esteem, teachers of young children must begin early computer experiences that will insure success.

First, we must have appropriate expectations for young children working with computers. These expectations must be derived from careful analysis of the tasks children must perform as they use each type of hardware, and each piece of software. Each of these tasks must be judged against one's knowledge of child development to determine which skills young children might reasonably be expected to possess or develop.

Secondly, we must help children develop the necessary skills that can be expected. Careful observations of a class and of individual children will help determine what off-computer experiences will be needed.

Finally, teachers must adapt some computer tasks to allow children to proceed with the learning task at hand without becoming frustrated by using the keyboard, for example. Teachers must also provide supplemental materials to help young children approach abstract computer tasks with the benefit of accompanying sensorimotor learning experiences.

The rewards of all these efforts are two-fold. Children will grow toward success with a powerful learning material, success that may have important implication for their cognitive growth and self-esteem. And it is in the children's success that there lie numerous rewards to the teacher not the least of which are pride and satisfaction. But when children are competent and independent at the computer, we can attend to it as we do the numerous other learning activities that comprise a good early childhood program. Because, after all, we are not computer teachers, but teachers of young children.

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Barbara A. Nye, Ph.D.

Microcomputers, Basic Skills, and Young Children

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Introduction

We talk about technology and learning these days as if we accept that microcomputers will have an active role in the classrooms of the future. Although many schools purchase and use microcomputers, technology and learning is more accurately used to describe the potential of the microcomputer within educational settings. Currently, microcomputers are not well integrated into the classroom curriculum, and the level of planning and coordination for integration of the computer as a "tool" for learning is likely to be a decade away.

Schools are faced with, some say plagued with, a multitude of reform priorities. Various groups push for reform in the learning process and in the curriculum. This push currently includes the influence of technological reform as we seek to clarify the role of the microcomputer in the learning environment.

The multitude of current reform movements follow many others. Some of the changes have been successful, and many others have been less than satisfactory. To be durable as an educational reform, any major proposed change in classrooms at a local, state, or national level must meet all three criteria listed below. (Kirst, 1984). The proposed reform must be:

1. structured in nature, highly organized (i.e. vocational or special education)
2. easily monitored (i.e. moveable desks, graded schools)
3. create new constituencies (i.e. foreign language, educational TV, typing as a separate class, school consolidation)

These criteria serve as benchmarks to evaluate the overall chance for a specific reform to succeed in most schools. Since reform is cyclical, these criteria also assist in estimating the potential duration of the reform. The magnitude of the reform's influence on schools depends on how long a reform movement endures and the imposed measurement of the benefits of the change.

Almost all reform movements in education return to one primary yardstick for measurement of their chance to succeed. Certainly, technology and learning is no different than most. Interestingly, this common yardstick for measuring the benefit of change has been a reform movement itself.

The yardstick commonly applied is student achievement in basic skills. What generic **basic skills** or fundamental abilities will be acquired by the students as a direct result or as an influence of the reform? In other words, will children obtain skills more effectively by using a microcomputer? Will that increased learning justify the costs associated with using microcomputers?

In the conference presentation which this paper documents, we did not dwell on the cost issues of technological reform in schools. Seymour Pappert (1984) asserts that the cost argument has been settled. He states: "I believe that right now it would be cost-effective to give every child a computer." He estimates that the average public school system spends about $25,000 per child (over 13 years) and parents spend another $25,000. A computer per child would cost approximately $500, or as little as $250-$300 on direct-purchase plans with the manufacturers. This would amount to only 1% of each the total cost for the education of each child. "Thus, if one computer for each child produced a 1 percent improvement in the child's education it would be cost-effective" (p. 25).

The cost issue is much more complex, however, than just the price of the computer hardware. Most studies do not consider the costs of teacher training, renovation of facilities, the adaptation of curricula to the new learning tool, or the development of "new" curricula and computer programs to insure that the

microcomputer is reaching its full potential as one learning "tool" in the classroom environment.

In the light of the basic skills yardstick, the Business, Youngsters, Technology, and Education (B.Y.T.E.) Consortium of the Tennessee State University Foundation, located in Nashville, Tennessee, launched a three-year study on computers in preschool classrooms for disadvantaged children. The B.Y.T.E Consortium conducts several on-going projects to develop appropriate curricula, teacher-training, parent/volunteer programs, and research design in the technology and learning area. Information from the Consortium's preschool project served as a basis for this presentation. Through this project, approximately 300 four- to five-year old children per year from 1981-1984 had access to a classroom microcomputer. Their basic skills were enhanced with the microcomputer experiences.

Basic Skills

First, we must understand that basic skills are not facts themselves. Basic skills are the abilities to use facts to gain further understanding or knowledge or to solve problems.

Basic skills do not vary by subject matter content area. They represent basic ways to process the facts within subject areas such as language, mathematics, or the sciences. They enable the student to understand facts and to use that knowledge in many ways. Basic skills undergrid the ability to learn.

Almost all schools have a list of core skills specific to the subject content areas. Only some schools and teachers, however, integrate these content skills with the basic learning process skills. The basic skills that are germane to the educational reform movement are listed below:

1. Observation
2. Communication (verbal/written)
3. Comprehension
4. Classification
5. Sequencing

The skills above are not specific to subject matter content areas, but are considered higher order thinking skills. Quellmalz (1985) writes that "assessments of students' thinking should be based on a core of essential skills that apply to academic, everyday, and novel situations" (p. 30). Looking at any one of these skills required in the overall learning process illustrates the necessity to teach the basic skills as well as subject matter content facts. Unfortunately, content facts or skills are mistakenly referred to as basic skills. Explicit understanding of the five basic skills listed above will improve subject matter instruction, reinforce the subject matter content facts, and improve the student's use of basic skills through application across subject matter areas. Rather than analyze the relation of technology to each of the five basic skills, as was done in the full conference presentation, only one skill area will be discussed in-depth in this paper.

Classification is a basic skill that cuts across all subject areas. The ability to take a new fact and arange it with a group of previously identified facts with similar attributes is ***basic*** to learning and to the problem solving process. Classification has several component parts including:

- **associating**—a beginning level of classification relating a symbol or object to something held in memory as an idea or a specific image (Copeland, 1974).
- **comparing**—a level of classification identifying similarities among two or more symbols, objects, events, experiences or processes.
- **distinguishing**—looking for specific features of symbols, objects, processes, or events to note how they differ from others
- **matching**—a laevel of classification that defines how these features are similar after locating two or more identical symbols, objects, or processes
- **contrasting** - a component of classification for notation of differences
- **sorting** - placement of objects, events, symbols or processes into groupings based upon attribute or function

It is clear that ***basic skills*** instruction is a cornerstone for learning across all subject areas. In *Intelligent School House* (1984) Peterson reminds us that "unfortunately about 85% of the computers in schools are programmed as teaching machines for drill and practice." Although education is a process transmitted by information (facts), it also must include the skills to utilize those facts for more complex tasks such as problem solving. In order to develop the capacity to solve problems and to become information users, children will need appropriate computer experiences for learning basic skills, not primarily for drill and practice on content facts.

The computer does present facts for drill and practice in a very patient manner. This is particularly useful for reinforcement, for remediation, or for individualized programmed learning. Yet, this approach denies the computer's potential to engage the child in the learning process—to master these generic basic skills versus only content area facts.

The teacher's role is crucial in the approach to promoting children's acquisition of basic skills. Facilitating a child's thought process to use learning experiences to gain basic skills is key. How an educator uses questioning, answering, summarizing and presentation of content are the primary elements in the process.

The microcomputer, when used appropriately, can result in the availability of a classroom tool that goes beyond drill and practice which is already available in most texts. The microcomputer can provide an enhanced learning environment. Software for microcomputers is available that incorporates questioning, problem-solving, and reflection in a developmentally appropriate manner.

The B.Y.T.E. Preschool Project

Reviewing a simple computer experience like "Build" from a LOGO curriculum illustrates this point. In the B.Y.T.E. preschool project, children created a microcomputer screen environment using up to 6 color blocks. They selected the block order, placement, and configuration. Classroom, manipulative materials provided a concrete beginning level for the microcomputer experience. The accuracy of block manipulation on the screen, the notation of the features of the blocks, planning for placement, or configuration of the blocks through classification skills were heightened by the microcomputer use.

Teachers in the B.Y.T.E. preschool project report that children learned the block colors, names of the control keys, the associated letters on the keys, and the directions such as left, right, up and down more rapidly than with metric blocks and/or work sheet experiences. The children attended more to details and spent longer time intervals in planning an execution of their designs on the computer screen, according to their

teachers. The children also verbalized more about position, color, and design. Children seemed to retain content knowledge (color, shape, size, position, etc.) for a longer period following the experience and to transfer the idea of classification to non-computer experiences during the discussions. An associated benefit was how quickly the children learned the alphabet through microcomputer keyboard use.

Conclusion

It appears that technology has an important role to play in educational reforms through the introduction, reinforcement, and refinement of the generic basic skills. Teachers, curriculum supervisiors, and producers of microcomputer related suppor materials should coordinate their efforts to make technology's role as vital as possible to the child's long-term acquisition and use of basic skills.

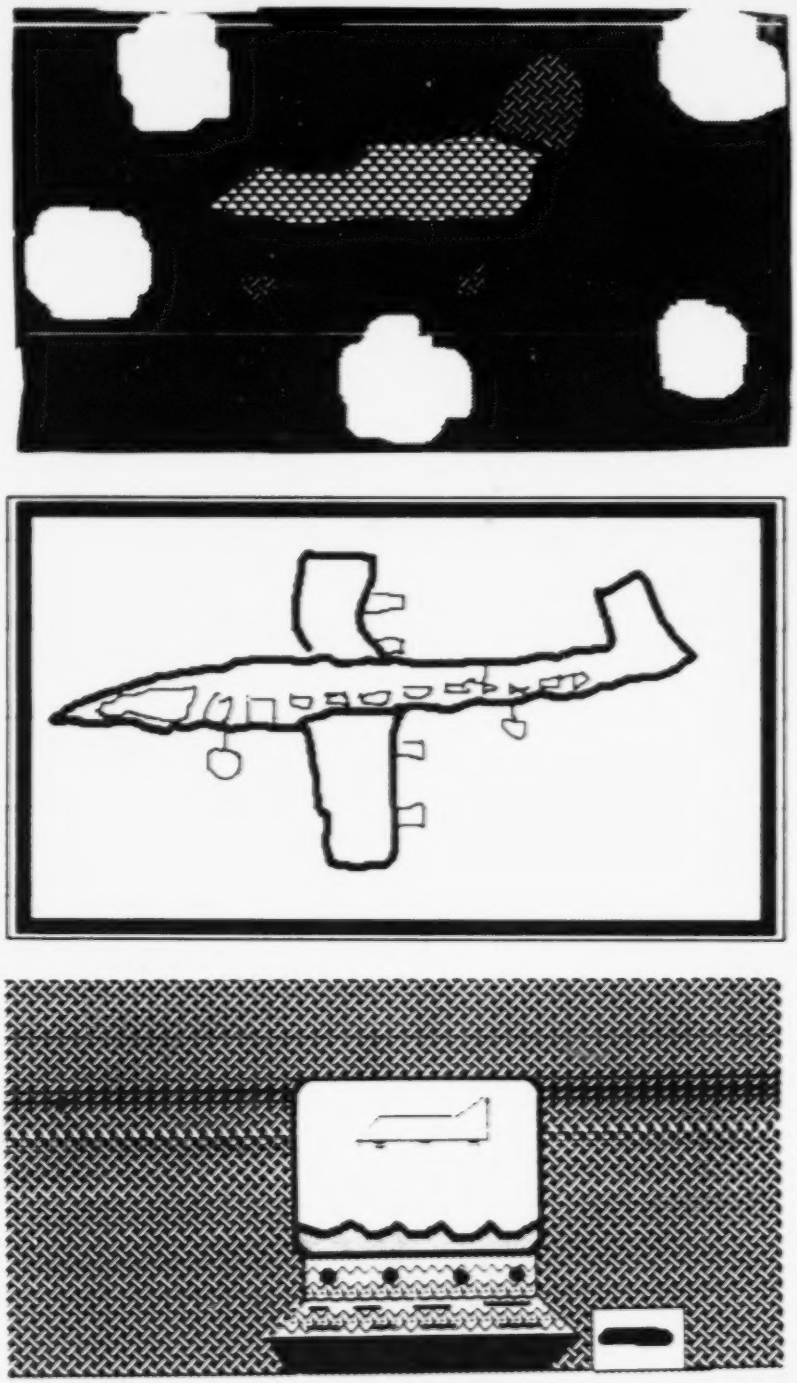
Cost will be a minor consideration, as with most reform movements, such as moveable desks, special education comprehensive high schools, and so forth, if the benefits of educational technology can be measured. Basic skill enhancement, communication about the educational and social impact of this tool, and its integration with curriculum subject matter will determine technology's lasting contribution to the educational process.

Computer literacy is only the beginning level of the influence of technological reform in education. Computer literacy cannot fully address the promise that technology holds for engaging the child in the learning process (learning generic basic skills, as well as quickly accessing and using factual information to solve problems).

The influence of the microcomputer on the learning process is far more important than the use of the computer to present subject matter facts. Reinforcement and remediation of facts through using the computer is very valuable. This current use of the computer is justified in most classrooms as long as we continue to focus our attention on the computer's primary benefit as a learning "tool."

The promise of technological reform in education will be realized, especially for the preschool and early elementary child when:

1) technology is used in classrooms to serve primarily as a vehicle for



Pictures on a Macintosh, made and printed by 3 children ages 5, 9 and 12 during their first 10 minutes to see or use this type of microcomputer. They decided as a group to make an airplane.

basic skill acquisition and secondarily for the transmission of factual information, and when the software produced supports the learning process itself, not just specific content area facts;

2) activities are primarily manipulative and constructive in nature and teacher's are not expected to enable learning primarily through lecture or worksheets (Kamii, 1985);
3) basic skills are introduced so that the child recognizes how problem solving and content knowledge are universal to learning and the learning process;
4) familiar content is used to introduce a skill and subsequent content is presented to challenge the use of the acquired skill of information (explore, discover, apply);
5) experience intergrating basic skills acquisition and the microcomputer are enhanced through questioning, summarizing, and reflecting;
6) the process of learning a basic skill, such as classification, receives more attention than the specific solution or time required to memorize content facts (i.e emphasizing 1 + 1 = 2 in kindergarten rather than emphasizing the sum of two numbers or objects is greater than either one number or object). Children must construct an understanding of number, not just be able to quantify sums.

The preschool years and those years before formal logic use is probable (prior to age 9) represent an optimal time for the integration of the microcomputer into the classroom. Children definitely function from a holistic perspective. Social, physical, and cognitive skills are interwined. The child is innately curious and accepting of process versus product learning. In addition, children accept alternative strategies and answers as processes to obtain content mastery. The abilities to observe, classify, communicate, comprehend, and sequence are not content-area specific and manipulation of concrete instructional material is regarded as essential for the construction of knowledge material is regarded as essential for the construction of knowledge during this period.

June Wright in "Preschool Logoworlds: Looking through Children's Eyes" provides a meaningful discussion of computer use with nursery and kindergarten children (Heller, Martin, and Wright, in press). *Computers in Early and Primary Education* by Douglas Clements (1985) is one of the best resources for understanding the role of computers in early elementary education in terms of classroom use and research issues. Also, "Logo in the Schools," a special double issue on Logo research, by the *Computers in the School* journal illustrates where we are in our research knowledge on technology and learning as it relates to teaching the LOGO language.

Young children who use microcomputers will probably be among the most techno-literate of our citizens. This is occurring not because they possess facts about machines or subject areas, but because they possess basic skills about the technological process and the learning process.

How well educational technology and learning endures as a reform movement should be judged by the basic skills yardstick, not content skill mastery. Microcomputer use has the potential to receive a very positive evaluation. Unlike many past reforms, educational strategists are taking the lead, and implementing appropriate technology and learning reform in many states. The current phase of the educational technology movement, unlike other reforms, receives both state and federal support and enjoys public, parental, and business community support.

Will computers enable teaching more, in new ways, more easily? That is the judgement of merit which the educational technology reform movement will face. Computer enthusiasts and education experts involved in this reform must keep in mind that "computers do not 'teach' young children. Experiences teach children; experiences with people, objects, and ideas" (Tipps and Mann, 1984). Appropriate microcomputer experiences focused on basic skills will engage children in the actual learning process. This active engagement is the primary mission of education.

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Milly Cowles and Mabel C. Robinson

An Analysis of Young Children and Learning Keyboarding Skills

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Can Children Learn to Type?

"You can give your child a head start in school with a _____ computer."

While the social, philosophical, and educational issues surrounding technology continue to whirl at an increasingly rapid pace in professional and academic circles, computers, word processors, and electronic games are being purchased and placed in as many schools, homes, and businesses as can be afforded. Few people doubt that "the machines" will disappear and persons who are expressing doubt, fears, and sincere reservations have made little dent in the market place.

Children learn to use computers rapidly, and when observed globally, most appear to be heavily engrossed in their operations on them. The question, however, that seldom has been asked is can young children learn keyboarding skills? Almost everyone now knows that children can use computers, that they can be used for enhancing the basics. The more important question is can they be taught to use them more effectively? If they can develop such skills without undue frustration, are they beneficial to the child's use of a computer? Obviously the first question must be answered before it is possible to investigate the second one. The National Diffusion Network published (in 1982) a review of 23 technology programs identified as the top ones in the United States. Of the 23 exemplary programs, not one dealt with the appropriate skills necessary to use a computer with maximal effectiveness.

Likewise in 1983, the Educational Testing Service issued its FOCUS 11 and in it was given the major recommendations for "computer literacy" and, again, basic keyboarding skills were omitted from the discussion.

Omar K. Moore singularly studied and documented the potency of the typewriter and the computer for young children in the 1960's. He was far ahead of his time and the work was largely ignored. Even as carefully as that work

was conducted, skill in managing the keyboard also was ignored.

Only business-oriented educators have seen the potential potency of touch-typing for children and one group has developed a programmed instructional package (Erikson, Seltzer, Steward and Jones, Nash and Geyer).

The major purpose of the study was to demonstrate whether or not five, six, seven, and eight-year-old children could learn keyboarding skills. A secondary purpose was to examine the relationship between typing skill development and motor proficiency.

A sample of 24 children was selected randomly from a summer school enrichment program population of 210. Of them, six were five-year-olds; six were six-year-olds; six were seven-year-olds; and six were eight-year-olds with half being girls.

The *Bruininks—Oseretsky test of Motor Proficiency* was used to measure individually the gross and fine motor skills of the 24 subjects. After arm and leg preference of each subject had been determined, two child development specialists administered the following subtests:

Gross Motor Skills:

1) Running speed and agility
2) Balance
3) Bilateral Coordination
4) Strength

Fine Motor Skills:

1) Response speed
2) Visual—motor control
3) Upper—limb speed and dexerity

Gross and Fine Motor Skills:

1) Upper—limb coordination

Teaching Techniques

The 24 subjects used IBM Selectric typewriters and a modified *Touch to Type Typing Program* developed by Nash and Geyer. The audio tapes accompanying the text were not used. All instruction was teacher directed in 30 minute-sessions for 19 days. There were 12-five and six-year-olds in one instructional group and 12-seven and eight-year-olds in the other one.

After the first day, the pattern of instruction used in both groups was as follows:

1) Review previous day's instruction and 30-second review timings.
2) Exercise for sixty seconds by bending and stretching while standing.
3) Type at one's own pace on day's lesson while monitored by instructor and assistant for correct technique.
4) Review of day's learnings.

Each subject's typing sample was collected each day. Thirty second timings were scored for speed and accuracy and recorded on the ninth, fourteenth and nineteenth days.

The goals for the five and six-year-olds were as follows:

1) Use correctly the paper guide, paper bail, cylinder knob, paper release, return key, space bar and on-off cradle.
2) Listen to and correctly follow oral instructions in relationship to touch typewriting.
3) Strike the keys learned by using the touch method at the rate of six gross works per minute on a 30-second timing using a 70-space line with no more than one third of strokes in error.
4) Complete one lesson every four days.

The goals for the seven and eight-year-olds were as follows:

1) Use correctly the paper guide, paper bail, cylinder knob, paper release, return key, space bar, line space indicator, margin levers, shift keys and on-off cradle.
2) Listen to and correctly follow oral instructions in relationship to touch typewriting.
3) Strike the keys learned using the touch method at the rate of ten gross works per minute on a 30-second timing using a 70-space line with no more than one third of strikes in error.
4) Complete one lesson each day.

Each lesson was observed by at least one child development specialist in order to measure time-on-task behaviors and to search for obvious signs of frustration, enjoyment, and perseverance. The two specialists had a 99 percent inter-rater reliability that covered 20 observations.

Results

Tables one, two, three, and four show the results of the rounded average gross words per minute (GWPM) and the average errors on 30-second timings. As can be seen, the older children made fewer errors and were typing words and sentences.

Table 1

Keyboarding Speed and Errors

Five-Year-Olds' Final Observation—Day 19

Rounded Average Gross Words Per Minute (GWPM) and Average Errors on Thirty-Second Timings on Isolated Strokes/Words

Name	Sex	Age	Strokes*		Words**	
			GWPM	Errors	GWPM	Errors
David	M	5	29	9	20	20
Ry	M	4	41	8	23	15
Amy	F	5	25	2	17	2
Gerry	M	5	22	8	14	10
Alexee	F	5	37	1	26	3

* Six sets of strokes = a; sl df fg gh as

** Five words = sad gas ask all fall

SPEED GOAL—87% of exercises were typed at least at the minimum rate of six GWPM

ACCURACY GOAL—93% of exercises were typed with no more than one-third of strokes per exercise as errors

Table 2

Keyboarding Speed and Errors

Six-Year-Olds' Final Observation—Day 19

Rounded Average Gross Words Per Minute (GWPM) and Average Errors on Thirty-Second Timings on Isolated Strokes/Words

Name	Sex	Age	Strokes*		Words**	
			GWPM	Errors	GWPM	Errors
Leigh	F	6	27	2	19	2
Kristy	F	6	24	1	20	1
Josh	M	6	33	10	4	2
Jason	M	6	25	3	22	3

* Six sets of strokes = a; sl dk fj gh as

** Five words = sad gas ask all fall

SPEED GOAL—87% of exercises were typed at least at the minimum rate of six GWPM

ACCURACY GOAL—93% of exercises were typed with no more than one-third of strokes per exercise in errors

Table 3

Keyboarding Speed and Errors

Seven-Year-Olds' Final Observation—Day 19

Rounded Average Gross Words Per Minute (GWPM) and Average Errors on Thirty-Second Timings on Words/Sentences

Name	Sex	Age	Words*		Sentences**	
			GWPM	Errors	GWPM	Errors
Sam	M	6	16	2	6	2
Jeff	M	7	24	3	10	9
Laura	F	7	19	1	9	1
Beck	M	7	19	2	9	1
Emily	F	7	20	2	6	2
Caitlin	F	7	34	3	13	1

* Words = sad gag hall all half fell shell walk

** Sentences = Ask a lad. Dad had a fall. Hal has a salad. She sells eggs. Al was awake.

SPEED GOAL—82% of exercises were typed at least at the minimum rate of 10 GWPM

ACCURACY GOAL—100% of exercises were typed with no more than one-third of strokes per exercise as errors

Table 4

Keyboarding Speed and Errors

Eight-Year-Olds' Final Observation—Day 19

Rounded Average Gross Words Per Minute (GWPM) and Average Errors on Thirty-Second Timings on Isolated Words/Sentences

Name	Sex	Age	Words*		Sentences**	
			GWPM	Errors	GWPM	Errors
Pam	F	8	23	2	12	1
Leigh	F	8	21	2	9	4
Scott	M	8	26	1	10	2
John	M	8	23	7	12	6

* Words = sad gag hall all half fell shell walk

** Sentences = Ask a lad. Dad had a fall. Hal has a salad. She sells eggs. Al was awake.

SPEED GOAL—82% of exercises were typed at least at the minimum rate of 10 GWPM

ACCURACY GOAL—100% of exercises were typed with no more than one third of strokes per exercise as errors

Table five gives the motor proficiency scores and the rank order for each age group.

Table 5

Raw scores and rank order for Fine, and Gross Motor Proficency

	FINE MOTOR	RANK ORDER	GROSS MOTOR	RANK ORDER	TOTAL	RANK ORDER	RANK ORDER TOTAL 5&6 YR OLD	READERS SCORE COLUMN
5 YEAR OLDS								
David	8	1.5	20	1	28	1	1	
Ry	8	1.5	23	2	31	2	2	
Amy	12	4	27	4.5	39	4	4	
Gerry	11	3	27	4.5	38	3	3	
Alexee	16	5	26	3	46	5	5	
6 YEAR OLDS								
Leigh	22	4	35	5.5	57	6	9	
Kristy	14	2	34	4	48	4.5	7.5	
Joshua	13	1	35	5.5	48	4.5	7.5	
Jason	17	3	30	3	47	3	6	
							RANK ORDER TOTAL 5&6 YR OLD	**READERS SCORE COLUMN**
7 YEAR OLDS								
Sam	18	1	33	3	51	2	2	
Jeff	35	6	34	4.5	69	6	10	
Laura	20	3	34	4.5	54	3	3.5	
Beck	23	4	37	6	60	5	7	
Emily	19	2	31	2	50	1	1	
Caitlin	30	5	29	1	59	4	5.5	
8 YEAR OLDS								
Pam	29	4	36	2.5	65	4	9	
Leigh	23	2	36	2.5	59	2	5.5	
Scott	25	3	38	4	63	3	8	
John	19	1	35	1	54	1	3.5	

Pearson *r's* and Spearman *rho's* were performed on each age group to find relationships, if any, between motor proficiency and typing performance. As can be seen in Table 6, statistically significant correlations were not found and a number of inverse relationships appeared. Examination of the previously given descriptive tables shows that one or two extreme scores probably skewed the description.

The daily observation made by the child development specialists showed the following:

1) Five and six-year-old children strayed from the typing task on the average of every three minutes.
2) Seven and eight-year-old children strayed from the typing task on the average of every six minutes.
3) Each child showed a different pattern of sticking to the task.
4) All children rushed into the room and sat down to begin the lessons with the exception of one child.
5) Signs of overt frustration were missing.
6) Children smiled and chatted informally with the four adults.
7) Environment was task oriented.

Discussion and Conclusions

Clearly young children can learn to type correctly and they can do so without frustration. The seven and eight-year-olds experienced success with words and sentences and stayed with the task whereas the five and six-year olds progressed only to words. Observations led to the view that being able to read was important and the date showed that gross and fine motor proficiency were highly related to the successful seven and eight-year-olds.

Studies are needed to determine the kinds of skills children need in order to deal adequately with key-boards whether they are typewriters or computers. Are children limited in their interactions with machines when proper skills are not developed, and when improper ones are incorporated into their operational schema?

Table 6

Pearson *r's* and Spearman *rho's* for Typing Scores and Motor Proficiency Scores in Five and Six-Year-Olds

	Pearson r	Spearman rho
Fine Motor w/GWPM Strokes	-.25(.25)	.16(.54)
Fine Motor w/GWPM Words	.1056(.40)	.11(.59)
Gross Motor w/GWPM Strokes	-.35(.19)	-.35(.19)
Gross Motor w/GWPM Words	-.46(.10)	-.53(.07)
Motor Total w/GWPM Strokes	-.32(.21)	-.18(.55)
Motor Total w/GWPM Words	-.22(.29)	-.25(.28)

In Table 7, is spite of the small number in the sample, a number of the correlations were statistically significant.

Table 7

Pearson *r's* and Spearman *rho's* for Typing Scores and Motor Proficiency Scores in Seven and Eight-Year-Olds

	Pearson r	Spearman rho
Fine Motor w/GWPM Words	.63(.03)*	.75(.006)*
Fine Motor w/GWPM Sentences	.56(.04)*	.65(.02)*
Gross Motor w/GWPM Words	-.34(.17)	.04(.45)
Gross Motor w/GWPM Sentences	.05(.44)	.09(.59)
Motor Total w/GWPM Words	.43(.11)	.56(.05)*
Motor Total w/GWPM Sentences	.54(.05)*	.55(.05)*

*p<.05

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Dennis A. Haslip

The Use of Computer Assisted Instruction with the Physically Handicapped Student

Dennis Haslip ***teaches at the Shrine School in Memphis, Tennessee, which serves children and young adults with various physical handicaps. He has developed a non-graded academic program and an adaptive physical education program. He utilizes technical communication aids which help severely involved children meet educational and vocational objectives and provide environmentalization training. He has developed a computer-assisted instructional program for the students at Shrine. Dennis has a Master's degree in special education from Memphis State University and has done postgraduate work in speech and hearing and in educational administration and supervision in special education programs.***

With the passage of Public Law 94-142 in 1975, public school systems were required to provide each child in the United States with an education appropriate to his or her individual needs. Specifically, this law demanded a unique curriculum, an Individual Educational Plan (IEP), specifically written for each handicapped child, while, at the same time, requiring that he be placed in the "least restrictive environment", an educational setting where, as much as possible, the physically handicapped student would be allowed to interact with his non-handicapped peers. To encourage this, Section 604 of the law provided for the use of technical aids and devices.

The financial implications of this law have been considerable for larger school systems, and almost insurmountable for smaller systems, both of which have had to hire special educators, adapt curricula, and initiate extensive record keeping activities. Education of the PH is extremely time consuming, both on the part of the teacher, and of the student. Teachers find themselves constantly waiting for feed-back from non-oral students. This interaction, whether hand-written or displayed in some other fashion (e.g.: type-writing, alphabet lap board, Bliss symbol board) can extend communication time, and, as a result, learning time, to the point of frustration, both for teachers and students. Geoffrion and Bergeron (1977) described the problem as follows:

> Perhaps the most universal characteristic shared by handicapped individuals is the inability to communicate effectively through conventional symbol systems. Various handicaps differ as to the locus of the communication breakdown, but once broken, the results of a lack of communication are very similar across handicaps.

The authors continued by indicating that the greatest visible effect was a failure on the part of the handicapped individual to learn the symbol system used by "normal" people. This has frequently been accompanied by loss of interest in any activity which involves communication and interaction.

Gearheart and Weisman (1976, pp. 83; 85) felt that adapted educational materials should be provided so that cerebral palsied students have every opportunity to survive in a regular classroom. They cautioned teachers by saying:

> It may take him considerably longer than the other (normal) students to complete an assignment because of the motor involvement, but he must be allowed to complete it independently.

Meyen (1982, p. 395) stated that, "because of the varied educational needs of the physically disabled, curricula must integrate adaptive techniques with a variety of educational materials." The author continued by saying that emphasis should be on the creation of new, and the adaptation of existing materials to meet individual needs. It must be remembered that, while on one hand, the damage which has produced the physical abnormality may also produce a mental deficiency, it is also quite possible that physical disabilities are not accompanied by mental deficiency (Schwartz, 1975, p. 41).

To summarize, since the passage of PL 94-142 in June, 1975, many educators have been confronted with an almost monumental task—that of educating a child with special needs, typically in a class-room designed for "normal" students. While these special needs are not impossible to deal with, they generally require a disproportionately large amount of time, both on the part of the teacher, and the student. Generally, the handicapped student takes longer to communicate, takes longer to learn, and requires specially designed instructional

materials. All of this represents teacher time which, to administrators, means money. As indicated above, however, this law also encouraged the use of technical aids and devices. Technical aid in the form of computer assisted instruction may be a very viable solution to the problems inherent in educating the physically handicapped.

Computer-assisted-instruction (CAI) came into existence in the early 1960's, probably due to the increasing general availability of main-frame computers, and to the programmed instruction movement, which saw CAI as the perfect medium in which to manifest Pressey's teaching machine, and Skinner's reinforcement learning principles (Gleason, 1981; Dance, 1980; Burns & Bozeman, 1981; Grinstein & Yarmish, 1981; Steinberg, 1977). With the birth of CAI came CAI research, with a majority of projects being carried out by the universities and business interests which could afford the abundant main frame computer resources necessary for CAI at that time. By the early 1970's, however, larger public school systems had become computerized, resulting in increased CAI studies at the primary and secondary levels (Jamison, Suppes and Wells, 1974). With the commercial availability of the first microcomputers in 1976 came an alternative to the expensive, and frequently temperamental main-frame computers, which added impetus to the CAI movement. At the present time, extremely cost effective microcomputer based educational systems can be had by almost any facility (Caldwell, 1980; McIsaac and Baker, 1981; Watts, 1981; Stevens, 1981; Daneliuk & Wright, 1981; Cavin, Cavin & Lagowski, 1980; Holmes, 1982; Mills & Stonier, 1982; Skyrme, 1982).

While a variety of seemingly beneficial instructional features are inherent to CAI (CAI is self paced, and provides immediate feed-back. It is adaptive, and highly interactive.) and are undebated, five facets of the effectiveness of CAI over that of traditional instruction (TI) have consistently been considered in the literature: (a) Student achievement; (b) Student attitudes toward CAI and/or subject matter; (c) Student retention; (d) Cost; (e) Learning time. Each of these variables has been studied repeatedly, often with confusing and contradictory results. Burns and Bozeman (1981) described the resulting situation:

> Various researchers have attempted to narratively review the research literature in an attempt to formulate conclusions and/or to establish a more broadly based case for CAI. These endeavors . . . have resulted in conflicting and inconclusive findings.

When used as the sole instructional medium, the effectiveness of CAI in terms of student achievement has not always been shown to be significantly better than TI (Dence, 1980; Edwards, Norton, Taylor, Weiss and Van-Dusseldorp, 1975; Vinsonhaler and Bass, 1972; Jamison et al., 1974). However, Holmes (1982), while admitting to the debatability of the CAI effectiveness question, indicated that a medium with the versatility of CAI seen only as effective as TI might still be advantageous in other areas:

> At the very least it must be admitted that a machine which can, when required, replace traditional instruction without deleterious effects on learning must surely be seen as an advantage for learners who have limited access to traditional modes of instruction, and perhaps those who do not respond well to those modes.

Herbert (1982) expressed similar sentiments. Reporting on a study which produced no significant differences between achievement levels of students in CAI and TI situations, he pointed out other observed benefits such as student paced instruction, reduction of paper work for instructors, and improved student attitudes. When used to supplement, rather than replace TI, evidence strongly supported the effectiveness of CAI (Vinsonhaler and Bass, 1972; Edwards et al., 1975; Chambers and Sprecher, 1980; Burns and Bozeman, 1981).

As pointed out by Clement (1981), student attitudes toward CAI have been found to be almost consistently positive at all educational levels. Clement indicated that this was probably due to five attributes of CAI:

> (a) self-paced (b) lack of embarrassment when mistakes are made (c) immediate feedback (d) a general feeling that they learn better through the computer system (e) lack of subjective evaluations; the computer bases its evaluations strictly on student performance, not on personal characteristics of a student. . . .

Chambers and Sprecher (1980) in a literature review cited six references indicating improved student attitude toward the use of computers in learning. Dence (1980) in a review of seventeen studies found evidence that students having experienced CAI had more positive attitudes toward it (CAI) than those students without any CAI experience. Magidson (1977), Herbert (1982), Cavin et al. (1980) and Holmes (1982) also mentioned positive student attitudes toward CAI and subject matter. Kulik, Kulik and Cohen (1980) in considering the eleven relevant studies in their meta-analysis of 59 studies found a "small" difference in favor of CAI in "course quality" as compared to TI. In the seven studies reviewing student attitudes towards subject matter an even smaller difference was reported, again in favor of CAI.

In terms of student retention Gleason (1981) stated that students taught via CAI had retention rates equivalent to, if not higher than those students taught by TI. Dence (1980) agreed with Gleason. Edwards et al. (1975) in a review of literature mentioned that, in the three relevant studies, the reverse situation was evident: students taught by TI had higher retention rates than students taught with CAI.

The topic of cost has generally been considered in terms of the cost of microcomputer supported vs. mini or main-frame computer supported CAI. Cavin et al. (1980), Caldwell (1980), and McIsaac and Baker (1981) pointed out that microcomputers were much more desirable for CAI than main-frame computers, and gave cost as a major factor. Chambers and Sprecher (1980) felt that the microcomputer had all of the capabilities of the mini-computer, plus color, graphics, and the potential for audio in- and out-put, but at a much lower cost. The smaller memory capacity of microcomputers was mentioned as a major disadvantage, however. The author continued by mentioning that, with mass production and improved technology, the cost of microcomputers was expected to quickly drop to the point of cost-effective uses of CAI.

It is in terms of reduced student learning time that CAI has its one seemingly indisputable benefit. An abundance of authors (Kulik et al., 1980; Kearsley, Hunter and Seidel, 1983; Chambers and Sprecher, 1980; Dence 1980; Lewellen, 1971; Magidson, 1977; Edwards et al., 1975; Gleason, 1981; Jamison et. al., 1974; Burns and Bozeman, 1981) reported savings in students' time ranging in estimates from thirty to as high as fifty per-cent over that of TI.

Apparently, the effectiveness of CAI with non handicapped students has been, at least to some extent, delineated. Its benefits, when used as a supplemental form of instruction are well documented, as is its ability to reduce student learning time. The following authors have expressed their interest in using CAI specifically with the physically handicapped.

Thorkildsen and Williams (1981) who described special education as an extremely "labor intensive educational process" demanding a considerable amount of one-on-one, and small group interaction felt that CAI may prove itself an economically feasible solution to many problems caused by PL 94-142:

> (This law) should also have significant impact on the use of computers in special education settings. The fact that every child is now to receive an appropriate education means that the teaching resources in special education will be stretched to the limit. Labor saving devices will be very attractive. The low density of the population and the diverse nature of their handicaps, along with the goal of placing children in the least restrictive environment, will result in these children being placed in small numbers in regular classrooms. The schools will be required to provide appropriate education for a small number of children in widely scattered locations.

That this individualization and self-paced educational system demanded by the handicapped can be realized in CAI is further testified to by others. A variety of authors (Jamison, Suppes and Wells, 1974; Clement, 1981; Carman and Kosbery, 1982; Magidson, 1977; Lewellen, 1971) felt that CAI provided the most highly individualized interaction between curriculum and student of any instructional method currently available. Embarrassment associated with the slow progress, and frequent mistakes commonly experienced by the physically handicapped while learning can be greatly reduced.

Hill (1976) indicated a belief in the computer as a solution to many of the needs of the physically handicapped for very basic reasons. Many of these students have graduated from pencils to typewriters due to the physical impossibilities associated with hand writing. Doing a math problem on a typewriter has its frustrations also, however, when one considers that most mathematical computations move from right to left, and most typewriters move from left to right. Mistakes are also a problem. Computers, on the other hand, can be programmed to move from right to left, and computer erasures are made by pressing a key. If the student can type efficiently enough to make the mistake in the first place, he can erase with a similar effort.

Papert, in testimony to the House Sub-Committee on Science and Technology (1977) stated that even the most physically involved person usually has some control over some muscle. Once that control has been identified, and in conjunction with appropriate electronic interface devices, it is generally a simple matter to program a microcomputer to respond to the movement, resulting in the formation of a channel of communications from human to computer. This linking of a handicapped individual to a computer more efficiently than simply having him use a head-stick on a keyboard enables a handicapped person to interact efficiently enough to become financially self-supporting. Papert termed use of a computer in this manner as an informational prosthesis.

Goldenberg (1979, p. 5) described the potential for computer aids to the physically handicapped as follows:

> The computer provides flexible technology that can so thoroughly enrich the experiences and communication of certain handicapped persons that activities and learning that were previously thought impossible for them become routine and easy.

Goldenberg described the handicapped child as being at a decided disadvantage when he "must mediate interaction with the world through coordinated motor activity." The author pointed out, however, that, with the adaptable technology of the computer, the same student can learn to communicate quite adequately. In addition, handicapped students who are exposed to the immediate feedback and experimentation permitted with computers and appropriate software experience a "striking change" in their autonomy (Goldenberg, 1979, pp. 12; 24). To summarize, Goldenberg (1979, pp. 30-31) states:

> In my view, it is the child's abnormal experience of the world (e.g., his lack of easy, fluent communication and casual play) more than his abnormal behavior (e.g., his inability to speak, write or walk) that handicaps the child.

The computer can provide a more normal interface between the abnormal student and his environment.

Vanderheiden (1981) felt that microcomputers were essential to the proper education of the handicapped. He stated that the "manipulation and exploration important to development may be impossible" without them. Using microcomputers with specially devised and individualized electronic interface devices might provide a means of manipulating objects on a TV screen, or in real space. In addition, Vanderheiden pointed out a more direct educational need which can be met by use of CAI. Almost by definition, the handicapped experience a slow rate of coordinated meaningful physical activity. This necessitates extended time for most educational tasks. For example, in a typical classroom discussion, the handicapped student may know the correct answer, but conveying the answer to the instructor may often prove to be too time consuming for all involved. In addition, such common educational activities as diagramming sentences, working a set of practice math problems, or writing a paragraph would all be such monumental tasks that even the most dedicated handicapped student becomes frustrated. As Vanderheiden stated:

> Since the need to see, read and write, take notes, and do independent work are necessary capabilities for receiving an education within our current system, the severely physically handicapped individual who lacks them is at an extreme disadvantage.

Appropriate courseware, coupled with the general tendency of CAI to reduce learning time, have the combined potential to solve many problems experienced by both the physically handicapped in learning, and special educators in teaching.

It is apparent that, while many "benefits" of CAI are still being debated, this educational medium still has much to offer the teacher who is attempting to educate a special needs child. CAI can be relatively inexpensive when compared to its human counterpart, and it appears to be extremely effective in terms of student achievement. CAI is adaptable enough to meet the needs of even the most severely physically involved student, and it is infinitely patient. The major strength of CAI, how-

ever, that of reducing learning time, meshes precisely with the major weakness of the handicapped student: extended learning time.

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James K. Hadlock & Sandra K. Morris

Computers and Classrooms: Physical Considerations

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A full report of this presentation is found in a paper by the same name which has been copyrighted by the University of Delaware. We include herein a summary of the suggestions contained in that work.

Introduction

The physical set-up of any classroom reflects the philosophy of the program and the personality of the individual teacher. Setting up a computer in the classroom should be treated in the same way. Our concern has been that the computer be treated as a curriculum material and not as curriculum itself. For that reason, we feel that the computer should be integrated into the classroom rather than creating a separate room or separate environment for the machine.

Furniture

- Needs to be low enough for young children.
- Check monitor height from child's perspective.
- Check monitor set-back—needs to be within reach so the child can point out what is on the screen and share with others.
- Standard tables for the age group of children may be better than adult computer tables because of height, the fact that two or more children may share a table, and also that these tables have enough area around the computer for other learning materials.
- If computers must be moved, place them on a low rolling cart to prevent damage in moving.

Spatial Considerations: Machine Configuration

- The teacher may be located in a chair positioned beside the computer to view both the child working at the computer and the rest of the classroom, and to be able to view the monitor when necessary.

- Make sure there is enough space for entering and leaving the area; for two or more to work together; for using various software which requires body responses or movement of a mouse or turtle.
- A magic slate or marker board may be helpful for word processing.
- A bulletin board may be used to post visual directions for computer operations or to show the software which can be selected by each child.
- In laboratory set-up, if children face the walls while working on the computers, they cannot share each other's work and the instructor cannot see frustration or anxiety in the children's faces.
- If tables are arranged so that computers are back to back on tables in the center of the room, interaction is increased, but there is little space remaining for related activities; it also could be a hazard with electrical wiring.
- If tables are angled from the wall, the teacher can see the monitors from one end of the room and view the facial expressions and the children can view others' work. This arrangement likewise leaves fairly large work areas for related activities and sufficient moving-about space.
- Rows of tables can impede movement and spontaneity of peer interactions. This configuration may be more suited to adults or older students.
- Computer tables may be integrated into the classroom in quiet areas, away from the traffic. If the tables are angled from the wall, there is space for 2 or 3 children to work, while the teacher can assist them and observe the rest of the room from that angled position.
- Cards with pictures representing the software allow children to choose the software program which the teacher can load into the machine.
- If more than one variety of machines are used in the classroom, group them according to type and function.
- Philosophical base for the classroom set-up includes:
  - the child is an active learner; provide space accordingly.
  - balance sensory materials, dramatic play, and first-hand experiences.

Other Details

- Allow space for entry way, lockers for coats, umbrellas, and other belongings.
- Consider access to bathrooms, public parking for parents, and barrier-free access for the handicapped.

Physical Considerations: The Computer Classroom

Electrical:

- You may need 2 or 3 outlets for each computer system depending on how many devices operate off of the main power supply.
- Each station will require 1.6 amps; 12 or 13 computer systems may operate on a single 20 amps circuit, without peripherals.
- For 12 computer systems, a 40 amps service could be split out into 30 different 1.6 amps outlets. Power strips may be used or 15 conveniently placed duplex outlets.
- Power may be furnished down from the ceiling or under a false flooring; consult local building codes.
- You may need power filters to eliminate surges in the power supply; or you may need a backup power supply.
- Consider the location of the power (on-off) switch on the computer. Typically, computer manufacturers locate these on the back of the system so that the power cannot be turned off accidentally. This is a difficult location for children to reach. Some manufacturers have front or side switch options.

Other Space Considerations

- Physical layout must account for traffic patterns as far away from the stations as possible to minimize potential distractions.
- Each station should have a 3-foot by 2.5 foot space for the computer. If you are using six-foot tables, you could arrange two stations on each one.
- Each station should have enough space to allow for students to write beside the computer, an additional 1.5 square feet. At least 10 square feet should be used if two pupils share a station.
- Two square feet per chair is needed, plus enough room to walk behind and beside the stations. Consult local building codes about aisle space requirements.
- Storage space is needed for manuals, blank disks, software, student coats and books, maintenance equipment, and other equipment not in use. Save some of the packing boxes and materials in case equipment must be returned to the manufacturer for repairs.
- A proctor's station or a lecture-teaching area may also be included in the space requirements as necessary.

Lighting

- Beware of reflections and glare on the screen. You can reduce the potential for glare by directing the room lighting directly downward.
- Maintain a generally low-light room with individual lamps at each station or select monitors with anti-glare screens.
- Darker, flat paint is best for the wall.
- Windows opposite the monitor offer the worst case of glare.

Cabling Needs

- Cables are not considered to be part of the computer or of the peripheral, such as a printer or modem.
- Differences in the type of cables and connectors must be considered before buying the equipment.
- Some peripherals, such as the modem, also require a port on the computer, in addition to the cable. These will have to be purchased separately and installed.

Environmental Considerations

- Most microcomputers cannot operate above 85 F.
- A too dry environment generates static electricity which causes chip failure.
- Too much humidity causes corrosion on various contacts.
- 50% relative humidity is considered ideal.
- Since both the bodies of the users and the machines themselves generate heat, you need to consider the BTU of heat generated by both when calculating the air-conditioning needs.
- Consider the noise of printers, cassette recorders used along with the computer, and other distractions. Head phones may eliminate sound pollution, and printers may be enclosed to control the noise.

Security Considerations

- Ground floor, windowed rooms are poor for security.

- Alarms can be installed on windows and scanning devices in the room.
- Consider limiting after-hours access, extra staffing with a proctor to control access, and extra insurance to cover theft loss.
- The machines may to locked into the desk.
- Avoid multiple entrance/exit points.
- Consider picture identification information at check-in.

Miscellaneous

- Installation of phone lines and data lines.
- Interior decorating of the room—plants, drapes, posters, bulletin boards, and other teaching aids.
- Eliminate all smoking, eating, and drinking within the lab. A nearby lounge might be possible.

One or Two Machines in a Classroom

- Power strip can furnish extra outlets.
- Same space and lighting considerations apply.
- Anti-static mat may overcome that problem.
- If the entire class needs to view a software presentation simultaneously, a large-screen monitor or TV could be cabled to the computer.
- Remember that every different brand of computer generates its video image differently and that you must test your computer's image on the monitor before purchasing the monitor.
- Security must be considered in each location.
- Chalk dust is an enemy to the computer and its programs. Don't install chalkboards in a lab. Use marker boards instead. Don't locate a computer station near an existing chalkboard.

Sandra K. Morris

Computer Camp Experience for the Young Child

Sandra K. Morris ***holds a Masters Degree in Life Span Development from the University of Delaware. In addition to her role as Master Teacher in the University of Delaware Preschool Laboratory and Supervisor of Student Teachers, Ms. Morris is a coordinator in the Computer Active Preschool Project (CAPP). She has worked as a consultant to the CAPP camp and has taught in it. She is currently involved in several research studies involving young children and microcomputers.***

Goals of the Camp

There were three majors goals for the 1984 Computer Camp for Young Children. The first was to provide a developmentally appropriate computer experience for young children. The following description of the camp, which appeared in a brochure distributed to schools and parents in the greater Newark, Delaware area, defines the goals of the camp more specifically.

"CAPP provides young children with successful early experiences with microcomputers. The computers will be incorporated into a developmental classroom setting and combined with activities to develop children's beginning computing skills including thinking skills and beginning reading and math.

Children will:

- develop beginning keyboard skills
- learn to use a variety of computers
- learn to use preschool computer software
- learn basic programming skills

Children will be introduced to basic programming commands in LOGO and elementary word processing."

The second goal for the camp was to provide a high quality computer education program for inservice and preservice teachers. This was accomplished through the week of training prior to the camp and during the practicum experience, or camp itself. This training and practicum enabled the teachers to:

- set-up and operate microcomputers
- begin basic programming in LOGO
- begin word processing with the Bank Street Writer
- select developmentally appropriate preschool software
- learn teaching strategies for introducing children to computers
- plan curricula that prepare children for computer use and extend skills children learn while using computers.

Lastly, the camp was designed to provide a research site for faculty and graduate students. Three research projects were conducted during the camp period. Tours, observations and discussions with community educators, administrators and faculty from the University and other colleges were encouraged. A total of twenty-one tour/observations were conducted during the 1984 camp.

The challenge of meeting these goals for 1984 was eased by the experience which was gained by the staff at the University of Delaware during the summer of 1983 and during the academic school year of 1983-1984. The challenge holds both administrative and teaching oriented tasks. Some of these tasks can be addressed independent of each other, while others are so closely related, they cannot be. For the purpose of organization, the administrative concerns and the teaching concerns will be discussed separately.

Administrative Concerns

Staffing

The first of the two camps was designed to serve a total of forty four- and five-year-old children. The children enrolled were old enough to have completed either a four-year-old or kindergarten program. During the second year of camp, the age range was extended to include six and seven-year-olds, and the two sessions were divided by both age and experience. Twenty to twenty-five children were enrolled in each session. For the first year, staffing consisted of an acting administrator, head teacher, a computer consultant, and a total of eight undergraduate students who were enrolled in an experimental course: Computers in the Preschool/Kindergarten. The second year of the camp was planned with some specific staff changes. This staff consisted of two master teacher/administrators, Cynthia Paris

and Sandra Morris, eight graduate students and two undergraduates who were again enrolled in the course: Computers and Young Children. Six of these students were responsible for planning and supervising activities for a total of two of the four weeks of camp. This high student/teacher ratio is certainly not the same during the regular sessions of the Preschool, but in many ways, the camp situation is unique. This type of staffing was integral to the success of the camp. For the most part, the children attending camp had some previous experience in a group setting, but had never come together as a group before. Some of the children had had experience with microcomputers before, some had not; some were reading and some were not; some had worked with similar software, some had not. By maintaining a high number of staff members, it was possible to reach the goal of providing an appropriate group and individual experience for each child in the camp. A variety of both hardware and software could be made available, and assistance could be provided as needed in each area of the room.

Supporting curriculum materials were generated by staff members according to the needs of the children as a group, and as individuals. These supporting materials could be observed and revised accordingly. Unlike a teaching situation which lasts throughout a school year, the staff had to make these observations and generate teaching techniques and methods in a relatively short period of time. Staff was encouraged to support each other in achieving each of these goals. With the high number of staff available, the quality and quantity of observations of children with materials was possible.

The changes in staffing from year one to year two was inspired by experience and knowledge gained from the first camp. Each session of the 1984 camp had a different master teacher, which provided a different perspective for the staff and also allowed the teacher who was not acting as head teacher for each session to act as administrator for that session. Tours and observations, paper work and technological assistance could be managed by the acting administrator, freeing the teacher to be in direct contact with children at all times. The second advantage was that by employing two master teachers, the schedule could be consolidated so that both camp sessions could occur in the morning. Having one teacher responsible for back-to-back sessions is not realistic. Lastly, the teachers could support each other with observations and the insight that comes only with being able to observe programming, teaching techniques and children from a perspective other than teaching.

Schedule

The knowledge used in making staff changes was also applied to schedule changes. In 1983, the camp was held from June 6 to July 1. These dates actually overlapped the public school teacher's schedule in the State of Delaware, which affected both enrollment and staffing. It was impossible for public school teachers to participate in the training session held the week prior to camp and it was difficult for parents to modify their child's schedule for attendance to camp so close to the end of school. The session was held during the month of July in the summer of 1984. This seemed to be more workable for staff and for families, although several children took vacations with their families for a portion of the camp session.

The camp ran for a total of four weeks for the children and a total of five weeks and one day for the staff. A week of training was provided for staff members prior to camp and a day of wrap-up and clean-up was held after camp was over for the children.

The daily schedule was also revised from year to year. During the first summer, camp was offered from 10:00 a.m. to 11:30 a.m. and from 1:00 p.m. to 2:30 p.m. During this past year, sessions were offered from 9:00 a.m. to 10:30 a.m. and from 11:00 a.m. to 12:30 p.m. The morning session for the first year was the most popular and seemed to work into summer family schedules best. Since the sessions the second year were divided by the age of the children, a morning session for each age group seemed the most reasonable. Each session consisted of a work period or free play time and one or two group meeting times as necessary.

Staff scheduling also played a part in this change. During the first year, staff taught for a total of four weeks, in either the morning or the afternoon. To gain experience with each age group, it was necessary to increase the daily teaching time and shorten the total practicum experience to two weeks. This did not affect the total number of hours spend in the classroom from the first to second year. The obligation for teaching included a pre- and post-session conference for each session. The required hours for staff were 8:30 to 1:00 p.m., though all staff spend many more hours in the center preparing materials, brainstorming curriculum and working with the software available.

Budget and Materials

The hardware and software used for the camp during 1984 was more extensive than the first year of camp. The hardware purchased for the original project was included.

This was:

- 2 Apple IIe computers with disk drives
- 2 Color monitors (one 25', one 14')
- 1 Tasman turtle robot
- 1 Atari 800 computer with disk drive
- 1 Color monitor
- 1 Hand controller
- 1 PLATO terminal

In addition, equipment was loaned to CAPP camp by a variety of sources, including other offices of the University as well as private business in the area.

This equipment included:

- 1 Atari 800 computer with color monitor and disk drive
- 1 Apple IIe with black and white monitor
- 1 Tandy color computer with television
- 1 IPM PCjr with green screen monitor
- 1 Printer
- 1 PLATO terminal

The software used in the camp can essentially be broken down into four types; graphics tools, beginning programming and word processing, and software designed to reinforce skills appropriate to the young learner. Approximately $1,700.00 was budgeted for software for the total project. A total of $1,200.00 was spent and the remainder is still being used to buy appropriate software as it becomes available.

It is difficult from an administrative angle to break down the specific costs of running a camp like this one. Much of the overhead was absorbed by the University, as it would be in any institutional setting. Costs for the rooms, for example, are not available since the building where the camp was held is in use during the summer regardless of camp

being held there. The more obvious expenses are broken down below.

1983 Summer Camp

Revenue — $2788.00

Expenses—

—Salaries and Fringe Benefits	$3396.00
—Miscellaneous	36.00
—Supplies and Equipment	508.00
—Office Supplies and Duplication	51.00

As these figures indicate, the camp operated with a $1,203.00 deficit the first year. These funds were provided by the University as a service to the Department and the community.

1984 Camp Budget

Revenue — $3740.00

Expenses—

—Salaries	$3200.00
—Supplies and Equipment (including software and hardware)	329.00
—Office Supplies and Duplication	34.00

Obviously, the camp fared much better financially the second year. Of course, the experience of running the camp and managing the revenue generated more efficiently was a major factor in this difference. The other factor is the increase in generated revenue. It is important to note, however, that camp is truly not a money-making venture, and could not be self-sustaining without the equipment which was in place from the original CAPP and without the existing facilities at the University of Delaware.

Publicity

Since tuition is the only source of revenue for the camp, publicity for the camp is critical to its existence. Much of the publicity the second year was done by word of mouth. In April, brochures were sent to all the families requesting information throughout the year. These brochures were also distributed to all the eligible children attending the University of Delaware Preschool. Other brochures were sent to public schools, child care centers and private schools as requested. Local newspapers, television and radio stations all became involved in providing information about the camp to the public. University and community publications also printed articles regarding camp.

Teaching Concerns

Curriculum

Without any doubt, the curriculum which has been developed in the past two years to be used in the camp setting is both unique and exciting. The staff for both years were challenged by the task of presenting the microcomputer to young children as both an idea and a material. That is, the goals for the children included learning to use the material appropriately as well as learning about the material and how it fits into the world around them. Recordkeeping forms were developed and were kept on each child in the camp in order to facilitate the changeover of staff, to develop materials according to individual needs and to write progress reports to parents at the end of each session.

The goals for children while using the machine included that they would be able to turn the computer on and off, use a touch screen, hand controller and keyboard effectively, load and unload discs, use a menu to select options and to work through a more complex menu which may include sub-choices. At the same time that the children were practicing these skills with the computer, they were using software which gave them the capability of saving, retrieving, editing and repeating their work. This gave the children the experience of reorganizing their work quickly and of learning about the unique capabilities of the computer.

Another ongoing consideration in the curriculum was to help children understand how computers are used in the world beyond computer camp and school. A field trip to the bank to inspect the automatic teller and its workings was followed up by activities such as building an automatic teller and acting out its use. A fast food restaurant was set up in a dramatic play area, and children used a program developed by a fourteen-year-old programmer-volunteer to place orders and add the cost of various menu selections. A program designed to simulate flight for training airplane pilots was demonstrated to the children by the same fourteen-year-old volunteer. A computer technician visited camp and took apart the Apple IIe disk drive, demonstrated her tools, and talked with small groups of interested children about how the computer works and what she does to help people who use computers. All of these activities gave children the opportunity to experience some uses of computers in the community.

In order to facilitate the children's understanding of the computer and what it can do for them, four types of software were made available. The computer can be used as a tool to develop the concept of colored dot graphics, (not painting), writing and editing, and printing and programming in graphics. In addition, the computer can be used as early as kindergarten to practice skills which are of particular interest to particular children. Choice of software is important to developing these ideas. It is important that creative responses are acceptable, that children have a reasonable amount of control over the changes that occur on the screen, and that the changes are consistent with the action taken on the part of the child. The computer also presents children with a unique set of problems, thus the opportunity to develop problem solving skills. What do we need to save this picture? How can you move the cursor in the way you planned? Will the computer be able to print your story if you turn the computer off? All of these are questions which can be posed and answered as children work with computers and the software which facilities their uses.

Supporting curriculum is just as important as children develop these understandings. Field trips and guests to the classroom offer one way of learning about computers. Other curriculum areas such as dramatic play, large motor, art, science, music, and blocks need to be represented when introducing the young learner to computers. Like any material in an early childhood classroom, computers do not stand alone. The abstract nature of this material gives even more reason to introduce it in a developmental context. Observation of children, flexibility while planning and good judgement must be exercised by the teacher who is developing this type of program. It is important that the activities are manageable within the framework of the teacher's style, the goals of the program and the individual children's needs.

Sandra K. Morris . . .

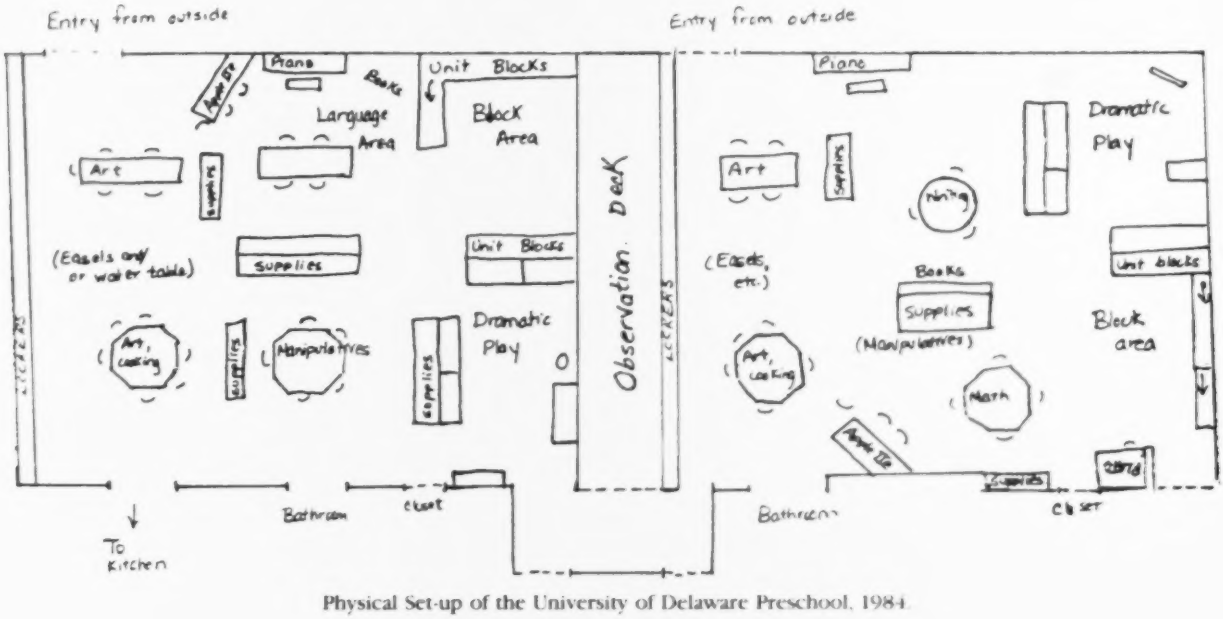
Physical Set-up

At the University of Delaware Preschool, the same rooms which are used as classrooms for the four-year-old and five-year-old groups during the regular academic school year are used for computer camps for young children during the summer months. During the regular school year, areas of the room are designated for certain types of activities and remain relatively the same throughout the school year. The materials do change according to the needs of the children or the particular unit of study. For example, cooking and sensory art materials can usually be found at a table of the four-year-old's classroom located close to the bathroom for ease of clean-up and door to the kitchen, but the cooking activity may change from fruit salad to facilitate learning about different food groups to making butter during a unit of study about the farm. The computers in both classrooms stayed in essentially the same place all year. The kindergarten class was equipped with a PLATO terminal which was located against a corner wall due to the need for telephone lines. The Apple IIe was placed on a preschool sized table facing out from the wall with a clear area for entry and leaving the computer, as well as a space for the teacher to position herself effectively for full room supervision. The software available along with cards with relevant information or directions were tacked to a cork strip above the table. The five-year-olds were able to remove the software, load the machines, and replace the software independently. Occasionally, an Atari 800 was added to the classroom, depending on the applicability of the software available.

In the four-year-old classroom, the Apple IIe was positioned in a relatively quiet area of the room, the language area. The table used for the microcomputer was angled from the wall, space was provided for two to three children to work comfortably and for a teacher to position herself in a chair close to the computer or at an activity close to the table. Occasionally, the Atari 800 was added to the room. During these times, this machine was located in a comparable position. Actual software was not made available to the four-year-olds. Cards with pictures representing the software, as well as its written name, were hung on the wall behind the computer. Children then asked the teacher to get the software and to watch as they loaded the machine. Choices of software were always made available to the children.

The computer camp lay-out was extremely different. Both rooms were made available to the children, with the doors to the middle hallway for traveling between the two rooms open at all times. The rooms are not open to both groups during the regular school year. The tables were angled from the walls when possible. The PLATO terminals present a bit of a problem, but positioning one teacher between the two terminals was very workable. Like computers and machines were grouped together. The Apple IIe machines and the Atari 800s were placed in different rooms to ease confusion which may arise regarding the different loading procedures for the two machines. Machines were grouped according to function also. The language area in the four-year-old room housed the Apple IIe with a printer for writing or typing stories, the Tandy Color Computer with the "Play with Language" software, and an Apple IIe with software which reinforced language or reading skills in general.

Much of the furniture which supported preschool activities such as unit blocks and dramatic play were not a part of the regular daily set-up of camp. The room arrangement was much more flexible in regard to these areas than during the regular school year. For example, the back area of the four-year-old room became a dramatic play area, housing an automatic teller built by the children for a few days during camp, and an area in



Physical Set-up of the University of Delaware Preschool, 1984.

the five-year-old classroom became a landing strip with unit block props for a few days. These same areas were used for a metric shuffle board game and as a dance studio designed to reinforce the concept of following steps in a procedure on other occasions during camp. The flexibility was built into the floor plan in order to accommodate a variety of supportive curriculum materials during camp.

Although the floor plans of these two rooms are not similar in actual physical set-up, the philosophical base which supports them is very much the same. The young child is recognized as an active learner and the space to be one is provided. The need for a balance of sensory materials, dramatic play and first-hand experiences are all acknowledged in both plans, with consideration for both space and practicality. Social development, self concept, and self esteem are supported through the accessibility of teacher assistance, peer interaction, and independence with materials. Both plans are an important part of the goal of the Computer Active Preschool Project to provide young children with a developmentally appropriate computer experience for young children.

Parents Contacts

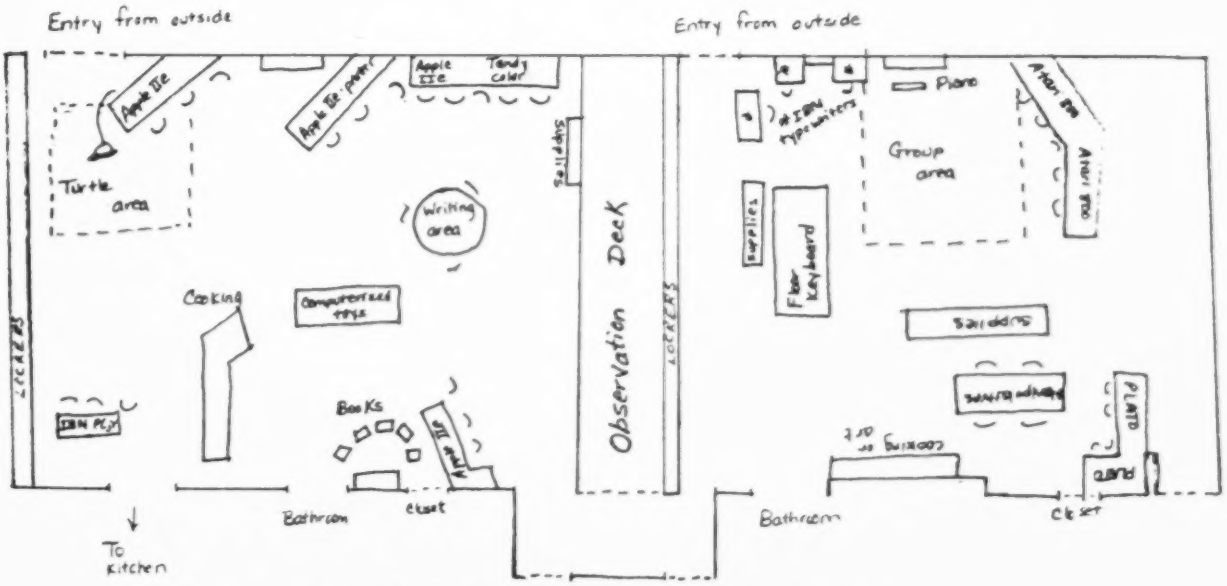
Communicating with parents effectively is a concern of every competent teacher. In the camp setting, relationships with parents have to be established quickly. Having a master teacher and administrator available to parents at all times during the camp day facilitated relationships with parents. Other activities which fostered this were weekly newsletters, scheduled observations, and an open house for parents held during the second week of camp.

Prior to camp, parents of the children enrolled in camp were sent a packet of materials including an emergency card, a form requesting some basic information about their child, a parking permit, and a cover introductory letter. This gave the staff some idea of the kinds of experiences each child had had with microcomputers and with groups of children. Allergy information, physical restrictions, and special concerns of parents were expressed in this communication.

Observations during camp were limited to one per week after the first week. A statement in the first newsletter reflects the reason for this policy. "We realize this is an excellent opportunity for you to watch your child in a group setting and welcome you to observe once each week of camp. Our experiences over the years at the Preschool indicate that daily observations create anxious parents and children. We ask your cooperation. Thank you." Scheduling of observations was handled through the College office staff. One of the master teachers of the camp was available to answer questions and to explain activities in general to all observers. Designated days were set aside for observation by staff only. This was done so that conversation in the observation booth could include a critical analysis of activities and needs of individual children. This type of conversation can, at times, be troublesome for parents and can also violate confidentiality.

During the second week of camp, the Open House Day was held. In the future, two of these events will probably be held. The first will be an information night for parents which will give them a better understanding of the daily schedule, the types of activities which will be available to children and the rationale behind the curriculum and methodology used in the camp. The second event will focus on the children, as the Open House Day did, and will involve having the parents spend the day with children as they work at the computers and related activities.

As a last communication to the parents of the children enrolled in camp, parents received a cover letter which summarized the camp experience and a report on their child in particular. Two sample reports are included here for the readers' information.



Physical Set-up of the Computer Camp for Young Children 1984.

Sandra K. Morris . . .

Debra

Debra was able to operate and load a variety of computers including the Apple, Atari, Tandy and PLATO. Each of these machines had a different operating procedure and Debra could easily transfer ideas and procedures from machine to machine with little assistance. She was able to use a touch screen accurately, use a keyboard efficiently, and use a hand controller. Her familiarity with a variety of keyboards really improved during the camp experience.

The skills Debra brought with her to camp contributed to the success she had over the past four weeks. Her reading ability enabled her to understand directions and to choose from a software menu proficiently. She used the computer to practice these skills, particularly at PLATO, and to create pictures, scenes and her own music. Debra frequently used "Magic Melody Box" on the Atari to experiment with pitch, and tempo of music she created on the computer.

Debra enjoyed working both independently and cooperatively on the computers. She moved through the two rooms with confidence, so that she was exposed to a wide variety of programs and software. She was very proficient at keeping track of her own experiences with the software, and welcomed new challenges provided by teachers.

Debra also seemed to enjoy computer related activities. She transferred concepts presented off the computer (during grouptimes and in small group experiences) to her work with the machines. She participated and contributed competently with peers and teachers. Debra seemed to enjoy herself and to enjoy learning immensely. She is a delightful, interesting child and we enjoyed her enthusiasm and creativity.

Benjamin

Benjy enjoyed using the Atari microcomputer and was able to turn the computer on and off, load disks, and use the keyboard and hand controller effectively. He was able to make choices from several pieces of software such as "Kindercomp" and "Sammy Sea Serpent", and was able to negotiate his way through the menu choices on these two pieces.

Benjy also worked on the Tandy microcomputer and was able to give directions to other children. The software available on these machines required Benjy to use his reading skills and to use a hand controller effectively to be successful.

Benjy spent a great deal of time working on the Apple microcomputer and especially the Bank Street Writer, a word processing program for children. He wrote a letter to a friend, saved it on a disk, and then came back to finish writing and printing his story. He spent a great deal of time typing his story on the computer keyboard and seemed quite pleased with his results. Benjy also enjoyed working with the turtle robot, experimenting with the Logo language commands of "forward, backward, right and left." Benjy was able to give the turtle a string of commands to follow. He demonstrated an understanding of the number concepts "greater than" and "less than."

Benjy tried many of the other activities available throughout computer camp and he seemed to enjoy trying new things. He participated enthusiastically in grouptimes. His favorite computer related activities included cooking (and eating!) and *anything* musical. Singing command songs, using the "repeat" command to play music at the piano, and experimenting with instrument sounds on The Learning Machine by Mattel were especially motivating for him. Benjy has an excellent attention span for this type of activity and takes a lot of pride in these accomplishments. His thoughtful approach to learning often involves a planned result which he enjoys sharing with adults and peers.

Conclusion

The camp has been successful in fulfilling the goals for the past two years, and with each year of experience, the staff feels that general operations have improved. The changes made from year one to year two have contributed a lot to the quality of the experience for both participating teachers and children. The response from the community and the children has been overwhelmingly positive. As stated before, the camp is not a money-making venture, nor will it be in the future. It is designed to provide children with a positive and developmentally appropriate experience with computers and to give teachers of young children some direction in integrating computers into their existing curriculum.

Randolph Steven Tipps, Ph.D.

Logo and Microworlds For Children

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Logo is a general purpose language which is being used as a "first" language for pre-schoolers, teenagers, and adults. Many people think of Logo as being for drawing squares and triangles. Many other graphics packages also allow for drawing of shapes. With Logo children draw shapes, but they are learning about angles and distances. While drawing, they are learning about the world of the Logo "turtle" and the rules which govern that world. This is a microworld in which electronic objects are manipulated to learn.

Logo is unique in its design as a computer language and in its design as an educational environment. Both its structure and its intended use are important in suggesting ways that children and teachers can use it toward educational goals.

Logo, the Language

Logo has many features which can be used for very complicated programs. Some of the features that make Logo a desirable language are:

1. It is *modular* so that parts of a problem can be solved separately. Then the parts can be put together.
2. It is expandable, or *extensible*. You can create new commands within Logo to perform specific tasks.
3. it is *interactive*. As soon as a command is entered, it is executed. This gives the programmer instant information about correctness of thinking.
4. It is *expressive*. Logo is designed as a language to think with and create with.

The qualities mean that Logo is not only a good language for a beginner, it has qualities which recommend it for very complex tasks. The applications of Logo are as varied as the tasks someone wants to perform.

Teachers and students use Logo in kindergarten and elementary grades, middle and high school, and college. Young children draw pictures which demand planning and thinking with Logo. Older students use Logo to learn about content in physics and language arts. Teachers can use Logo as a tool for learning about specific ideas.

As teachers become more familiar with Logo and its potential, they should strive to bring it into the classroom as a tool for discovering ideas. In Logo, discovering ideas is done in a microworld.

Microworlds for Young Children

A microworld is a place to play with electronic objects, much as the block corner is a place to play with wooden objects and the art center is a place to play with colorful objects. Manipulation and control is a primary feature of a microworld. However the objective in the block corner is not simply mastery over the sizes and shapes of blocks or the piling them up into a building. Instead the educational objective evolves from the understanding of symmetry, balance, enclosure, and number which are embedded in the materials.

Likewise the objective of a microworld is not the moving of turtles or drawing of shapes. The real object of manipulating electronic turtles is understanding—of distance and angle, shape and size, speed and time which are built into the microworld.

Logo is a microworld for children to explore concepts. They produce scenes and events which are sources of joy and amazement. The product is tangible evidence of the learning process. Within the turtle environment, countless other microworlds exist which teachers can also use. The Texas Instruments Logo Curriculum developed at The Lamplighter Schools is a collection of microworlds already created for childrens' use. These activities use sprites (or dynamic turtles) which are part of TI Logo. The sprites carry shapes such as cars, trucks, rockets, balls, and garages. The Logo movements have been preprogrammed so that each key controls a different result.

Randolph Steven Tipps . . .

Microworlds can be used or misused depending on a teacher's understanding of what a microworld is. If the microworld is seen as video games, they simply let the children move objects around, learning the mechanics of the computer. This teacher concentrates on locating buttons.

"Here is the button for left, here is the button for right."

At a higher level, the teacher sees the mechanics of the computer as a way to allow children control over the microworld. The teacher encourages exploration and manipulation of the objects.

"Can your car move in a circle?"

"Which stars can your rocket touch?"

Finally, a teacher who sees the true potential of the microworld poses questions of understanding. Looking at a screen with several cars and several garages, the teacher might challenge a student.

"Are there enough garages for your cars?"

Or the teacher might simply provide words to explicate is already on the screen.

"You have a car in every garage. There are the *same* number of cars as garages"

Using the keyboard is necessary, manipulating the objects is fun, but seeing relationships which exist is the substance of educational microworlds. The three levels are not independent but interdependent.

The microworlds in the TI Logo are samples of microworlds which can be invented for other machines and other versions of Logo. Many other activities which allow electronic control are also available in the form of construction sets and simulations. The construction sets and simulations are first cousins of the microworlds. Children can paint and draw with the computer. Children can type the alphabet and make personalized greeting cards. They can build buildings from shapes. Children can simulate adventures with dragons and tigers or robots.

Although electronic objects can represent many ideas, they should not be used to the exclusion of real objects. Young children in the pre-operational and transitional phases must have real blocks and real cars and real paints. The computer is another way of exploring ideas and another way of achieving control. When used in the context of a well-rounded early childhood setting, it can be an important learning tool.

In summary, the unique characteristics and purpose of Logo are best served when teachers understand the philosophy of Logo. Here are four suggestions for implementing a Logo program with children.

1. Children and adults need to have time to explore with Logo.
2. Making mistakes, finding them, and fixing them are important skills in programming. Turtle graphics makes mistakes visible so that you can think about them.
3. Avoid using recipes with Logo or telling people exactly how to do things. They will learn more by discovering themselves.
4. Logo and how we use it will change as we have more experience. Current microworlds, simulations, and construction sets are just a hint of the future.

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Louise Robinson & Leslie F. Thyberg

Logo, A Language for Children of All Ages

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Introduction

"This course of study in Logo has set fireworks off in my head," said a graduate student from Indiana University of Pennsylvania. Logo, a language for children of all ages, is making its way into schools and homes around the world. There are many fine resources available to aid parents and teachers in learning the essentials of Logo, but the market is not yet flooded with materials on how to effectively implement Logo. We will attempt to address that need in this paper by sharing some of our thoughts and experiences as two individuals who have implemented this exciting new computer language in a variety of settings, K through college. In particular, we will highlight pre-computer activities, classroom implementation, parental involvement, and teacher training.

Seymour Papert, Logo's primary public advocate, conceptualizer, and researcher was heavily influenced by Jean Piaget. Therefore, Logo's model for building intellectual structures starting at the concrete level and moving toward the abstract is not coincidental. When one is learning something new, regardless of one's age, it is to the learner's benefit to create a concrete, tangible foundation on which more powerful goals can be built. With Logo, we have found it to be extremely helpful to begin instruction with pre-computer activities that are concrete in nature. For example, Myrtle, the two-handed turtle puppet is used to introduce the first primitives that will be used. The "Myrtle Says" game, played just like "Simon Says" is the first activity.

Because most classrooms do not have the luxury of one computer for every students, "hands-on" time needs to be maximized. The use of pre-computer activities such as "Myrtle Says" is strongly suggested. These activities help prepare the students so that their actual computer time is purposeful and positive. While most Logo learning ought to be discovery oriented, providing focus

to the learning process helps make it a more constructive and productive experience.

At Logo '84 in Boston this past summer, Molly Watt used a slogan that we found to be another useful and effective means of moving from the concrete to the abstract. It goes as follows: "Tape it, walk it, turtle talk it." Its incorporation of Piagetian principles gives children a tool with which to solve their graphics problems.

Classroom Implementation

Logo in and of itself will not make the impact on education for which it has the potential, if it is not effectively implemented. The key variable effecting Logo is a cultural one. In other words, the classroom environment must be a microworld conducive to learning and empowering its students. One of the reasons Logo is potentially so powerful is because it enables the user to take the abstract and simplify it. It appeals to non-technical people and supports learning in natural ways. It gives the user power over his or her micro-environment and creates a natural connection to content areas such as art and geometry. In its truest and purest form, the role of the teacher shifts from that of lecturer and focal point to one of facilitator and guide. This is a radical deviation from most classroom learning as we know it today. Perhaps Leslie's initial experiences with Logo are a good illustration of what the Logo philosophy is all about.

Leslie first encountered Logo three years ago when she has asked to teach a pilot Logo program for a summer computer camp sponsored by a collaborative venture between the Learning Research and Development Center and Falk Laboratory School, both of the University of Pittsburgh. Having had no prior computer experience, she spent two intensive weeks prior to the start of the summer program being trained by a research assistant at the research center. The trainer's approach was a wise one, although Leslie was not so appreciative of it at the time. Whenever a difficulty arose, Leslie would ask, as most anxiety-ridden students are prone to do, "What's the right answer?" or "How do I do this?" The trainer's response was always an open-ended prompt, such as "What do you think will happen?" or "Why don't you try it and see what happens?" While initially frustrating, there was a significant benefit to be derived from not being given "instant answers." Steve Tipps summarizes it well in his December 1982 column in the *National Logo Exchange* "The same mistakes and struggles which the teacher goes through will make them more understanding and responsive to the frustration of learning. Remembering when we didn't know how to read or multiply or remembering how we learned is difficult. Working with a programming language, however, is a constant learning experience which starts with the first command." (*National Logo Exchange*, Vol. 1, No. 4, Dec. 1982, p. 3) The difference is in whether a "drill and kill" approach is taken such as "Two plus two is four, rather than an open-ended one that encourages creativity and problem-solving such as "How many different ways can you think of to get four?" The implications of this are that students working in such an environment will need ample immersion in a Logo-rich environment to maximize their hands-on computer time. Regardless of the computer per student ratio, extreme caution must be exercised by the teacher to prevent Logo from becoming a lock-step, cook-book, drill and kill course which fails to meet the philosophical considerations of a rich learning environment.

Logo is a microworld that is meant to be shared. It is an environment which allows children to learn from one another, to brainstorm together and share their solutions, and to create and collaborate productively. Interaction is one of the key elements in successful Logo implementation. Group projects are an effective method for developing a collaborative spirit. The teacher can break the students into groups and have each group create a thematic landscape based on some predetermined element, such as a circle or an arc. An example can be given showing how, using that procedure, another landscape element can be created. For example, birds and flower petals can be generated using arcs. The groups can brainstorm other examples of landscape elements. In turn, a superprocedure can be assembled, combining all the subprocedures. There are to be no limits in a Logo learning environment. Just as in all good education the needs of the individual are recognized, in a good Logo environment students are encouraged to proceed at their own rate and not be held back waiting for the rest of their peers or for direction from the teacher. Students are also encouraged to support each other in their efforts. Teachers need to be willing to use an open approach, accommodating for some students who are able to work abstractly, and supporting those who take more time to explore or need to work concretely, and creating situations in which a variety of student types can work collaboratively to stimulate and enhance their learning.

Too idealistic? No. This is the type of environment that both Leslie and Louise have created. How? Some practical suggestions on scheduling and management issues may help shed light on the ease of such an approach.

Practical Suggestions

1) **Where Do I Put the Computer?** The computer should be placed to serve the needs of the class and of each student user. We have found it preferable to keep it in a location where other students can share in the individual user's discoveries. Watching the "action on the screen" can be a stimulating invitation to the next user. Additionally, the computer will sometimes be used for demonstrations or instructional purposes. Locating it where it can easily be viewed by the whole class is useful. When considering placement of the computer, another important tip is glare from windows. If the screen faces a window, it will reflect the light, making it difficult to see the screen image. Once the computer is well located it can readily become an integral part of the classroom.
2) **How Do I Fit Logo in My Already Crowded Schedule?** In reality, Logo has rich content area applications ranging from turtle geometry to language arts to problem-solving strategies. Learning principles from Logo are applicable to all learning. Strategies for breaking a problem down into smaller parts are similar, regardless of whether the topic is math, reading, or computers. If one views Logo as a tool for learning, it will have broader applications in developing students' skills and reinforcing concepts they have already mastered.
3) **How Do I Assign Time on the computer?** It depends on what works best for you organizationally. Students should be provided with regular, frequent time on the com-

puter. Shorter more frequent intervals are more effective than lengthy, infrequent ones. Students should have a minimum of thirty minutes a week on the computer to have any impact at all. It's fine to schedule students to use the computer while other competing activities are going on in the room. Having students work in pairs is advisable, so students will have a partner to help when creating or debugging their projects.

4) **How Do I Keep Debugging from Bugging Me and My Valuable Instructional Time?** Appointing several "computer consultants" in the classroom is one effective means of keeping the teacher free from unnecessary student questions. Resource charts or similar aids also provide the students with some immediate assistance. Encouraging students to work as partners and assist each other is also a way to ensure that everyone actively shares in the learning process.
5) **How Do I Keep Track of What They're Doing?** Journals, graphics, printouts, and saving work on diskettes are helpful tools. Student notebooks can include student records of exploratory discoveries, future plans for projects, a chart or list of commands or procedures, graph paper, error message logs, and any handouts they might receive from you. Student self evaluation is also a powerful tool!
6) **What Are Some Resources for Me to Use?** A large posterboard chart of the keyboard, student made command charts, reference cards, puppets, and teacher-made or commercially generated games are a few suggestions. There are also several fine Logo manuals and texts available in a variety of bookstores that serve as good resource material.

Public Relations

One of the richest resources available to support classroom implementation of computer instruction is parents. Parents are eager to be involved, in part because big business and advertising hype have pushed them in this direction. The slogan of the future may well be, "Johnny can't compute", or so parents are led to believe. Regardless of their motivation, parents have proven to be our most avid supporters. It is important to recognize that Logo is being used in many settings other than schools. Hosting periodic "drop-in" days for parents, colleagues, or the local community to see what the children are learning is one mechanism for creating interest and support. Both Louise and Leslie host a formal open house for parents and university personnel. We find this to be an effective ice-breaker for those persons unfamiliar with Logo or even microcomputers themselves. Students present projects that they have developed and are often able to articulate in a delightful, non-threatening manner the powerful learning that they are encountering. These presentations can cover topics such as the difference between super- and sub-procedures, an orientation to the computer keyboard and elementary level commands, and highlights of the history of computers.

Another significant part of the open house approach that we have found to be extremely successful is the use of a continual video display of the children's favorite computer-generated graphics. The children choose their favorite "work of art" and submit it for the display. A program can be put together that runs each student's picture on a fullscreen then to a splitscreen with text displaying the name of the "masterpiece" as well as the name of the "artist".

Another avenue we continue to use for public and parental relations is the publication of a student computer newsletter. A few ideas for the newsletter that we have found to be popular are: a regularly featured column from the teacher; student's screen printouts; and student authored stories and reports. Publication of this is facilitated by the use of the Bank Street Writer.

Teacher Training

One of the attractions of Logo is its vision for "human-ness." The teacher's role is to prepare students to live in a technological world while delicately balancing its use. The teacher is undoubtedly the most critical variable in Logo use. Molly Watt describes a Logo teacher as being a: "demonstrator, teacher, lecturer, teller, time structurer, problem setter, management solver, arbitrator, helper, decision maker, challenger, technician, model learner, collaborator, process sharer, question asker, observer, admirer, enjoyer, documenter, and idea extender" (*Creative Computing* (10), Oct. 1982, 112-129). No small task, even for a super-human! How can one individual possibly do all this and still teach all the required subjects during a given day? It may sound as though a teacher has to know everything in order to effectively teach Logo. Not true. "Most needed for teaching Logo are teachers who are willing to learn. . . . After the willingness and will to learn are accepted . . . ways to build skills are possible" (*National Logo Exchange*, Vol. 1 (No. 4), Dec. 1982).

Local school site educators are the key to successful training of teachers in using Logo in the classroom. While there has been significant growth in Logo use in the past few years, future development will depend on the majority of staff members in the school becoming Logo-using educators. Needless to say, the traditional one-day in-service approach is inadequate for such a goal. In order to gain teachers' involvement in Logo one must make them comfortable with it and show them ways that it can contribute to them personally and professionally as well as how it will benefit their classrooms. Educators learn best from colleagues. Training is more effective if the leaders have the credibility that comes from being local practitioners who band together in a supportive fashion. Both of us have "networked" together and find that our "cooperative" learning is not unlike the peer partnering that we have in our classrooms. Two is better than one! This is not to say that we have not encountered obstacles along the way.

Some obstacles to properly tooling teachers in the applications of Logo are:

1) **Myths** about Logo based on insufficient or incorrect information. For example: "Logo is just for young children." Providing correct and additional information is an effective way to counter such misconceptions.
2) **Fear of failure** or not knowing the "answer" are difficult for the traditional teacher, especially if there is an audience. Stress the uniqueness and the power of learning from mistakes.
3) **Lack of time** is a significant obstacle. Some teachers may feel they do not have enough time or energy to spare on computing. Helping them prioritize and set specific goals so that they can see the personal rewards and instructional "pay-offs" to be had are important in overcoming the intense feelings associated with a perceived "technological burden."

How can adequate teacher training

be accomplished? Thoughtful Logo training courses that incorporate the philosophy and long-range commitment of a "Logo culture" need to be taught alongside the technical aspects of the language. Research needs to be conducted in helping teachers understand what students are actually doing with Logo so that they are not only well informed, but effective. In addition, teachers need to be provided with routine opportunities to learn new ideas, update their learning, share with their colleagues and verbalize their frustrations and victories.

Logo is more than a programming language. It is a culture and a movement. "It can encompass many styles, possibilities and directions. . . . What unites us is a vision of what learning environments could be: rich with experiences, ideas and people that break down the barriers between disciplines, between teacher and learner, and between people with different learning styles. It is the excitement of this vision, and the potential embodied in Logo to create this vision that brings us all together . . . " (Dan Watt, panelist paper, p. 29, Logo '84).

Kerry Olson & Dave Katz

The Electronic Forum on Young Children and Computers

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Introduction

The number of young children who have access to microcomputers is rapidly growing. Technological advances within the past several years have greatly reduced production costs, while expanding the capabilities and usability of the microcomputer. As a result, microcomputers have become an affordable addition to many home and classroom settings. Even the preschool aged child is able to engage in certain applications. An array of software specifically designed for use with and by young children is currently available, representing a wide range in quality and developmental value.

These recent trends—widespread household use and the integration of computers into early childhood programs across the country—present parents and teachers with a number of questions and decisions. Addressing the issues can seem like an overwhelming task . . . information, instruction and research lags behind the rapid introduction and marketing of hardware and software products. When considering the introduction of microcomputers to young children, perhaps the question to precede all others is "why?" What is the rationale for integrating the microcomputer into a particular setting? How does it support the philosophical approach and educational goals of the learning environment? As with any other potential learning tool or area of the curriculum, the microcomputer must be questioned in terms of its ability to "match" the cognitive abilities and behavioral competencies of the young child. Decisions regarding why and how microcomputers should be introduced to the early childhood setting must be based upon what is known about how young children learn and develop.

In response to the need for guidelines and activity ideas, an increasing number of written resources, workshops and instructional programs for parents and teachers have been developed. Those

involved in the task of selecting, implementing, designing and/or evaluating computer activities for children are finding ways to share and learn from one another's experiences through newsletters, journals, conferences and various forms of "networking." The computer itself can contribute to this interchange, for it is an excellent communication medium.

A computer based conferencing system, such as the Electronic Forum on Young Children and Computers (EFYCC), utilizes microcomputers, terminals and modems to facilitate timely, ongoing exchange of information. It allows individuals to "discuss" a topic or issue even though they may be participating in the conference at varying times and from different locations. This ability to cut across time and distance barriers makes it possible for participants to connect with the system at their convenience and to retrieve and selectively respond to the ideas, questions and experiences of others.

Purpose

The purpose of the Electronic Forum on Young Children and Computers (EFYCC) is to address issues related to microcomputers in the early childhood setting (classroom and home). Educators, parents, researchers, software developers, students and others are invited to share their ideas, questions and experiences. The Forum does not intend to advocate any particular position or approach, but to provide a means of open discussion. Ideally, it will provide a vehicle for sharing diverse viewpoints, as well as a means for individuals to link with others with similar interests.

Organization

The Forum is a storehouse of information which is organized into a series of ITEMS. Items are entered by the participants and usually present a single question, problem, or idea. An item could be a springboard to an ongoing discussion of an issue. It could announce an upcoming event, such as a conference or seminar. It could review a publication or product and request further comments. It could pose a question regarding a specific problem ("How do you connect a joystick to an Atari?"), or ask a more open-ended question regarding a broader topic ("What are some of the physical considerations of setting up a computer center in the classroom?").

Once an item is entered into the Forum it can be viewed and responded to by the other participants. A response could be a comment, solution, or any other relevant material. Each item and its chain of responses form an ongoing discussion . . . one among many which continue simultaneously within the Forum.

The Forum keeps track of which items and responses have been viewed by each participant (identified upon logging in with Forum User ID and Password). When a participant connects with the Forum, a list of the new items and new responses are given. The participant then has the option of reviewing and/or printing any or all of these items and responses.

One of the first enhancements to the Forum will be the ability to access items and responses by a key word or phrase. With this facility one could become more selective in reviewing the content of the Forum, accessing all information concerning a specific area ("teacher training", "Apple IIe").

The Forum user interface and structure is modelled after the program CONFER, a popular mainframe-based conferencing system, written by Bob Parnes at the University of Michigan.

Content

Topics to be included for discussion in EFYCC will be determined by the participants. The Forum organizers have presented several items to provide instruction and information on the Forum and to initiate discussion. Active participation is what makes the Forum work—participants are encouraged to present items which reflect their needs and interests.

Initial EFYCC Items:

- Item 1 EFYCC Instructions for Use
- Item 2 EFYCC Introduction and Guidelines
- Item 3 Comments/Suggestions for EFYCC
- Item 4 Changes and Enhancements to Forum Software
- Item 5 List of EFYCC Participants
- Item 6 Preschoolers and Microcomputers: A Developmentally Appropriate Match?
- Item 7-? To be determined by EFYCC Participants

Possible additional topics include:

- Ideas for Integrating Computers into the Classroom
- Hardware Reviews/Questions
- Software Reviews/Questions
- Publications Review
- Teacher Training
- Computers in the Home

Registration

The Electronic Forum on Young Children and Computers can be reached, using a terminal or microcomputer and a modem (a device allowing the exchange of computer information over a telephone connection).

At present, the Forum operates using a single phone line, allowing only one participant to use the system at a given time (other callers would receive a busy signal). The Forum will support both 300 and 1200 baud modems, and will automatically detect which is being used. The Forum supports full duplex, 7 data bits, one stop bit, and even parity. Registration is available on-line.

The Forum is available only on a limited schedule, due to the fact that the Forum is implemented on a microcomputer which must also be used for other purposes. Significant expansion of these hours will be dependent upon acquiring a computer system dedicated for use with the Forum. This possibility is being explored.

The Forum is effectively open to the public. It is offered as a free service to interested participants.

Etiquette

The Forum is a new kind of social experience to most people. As such, it requires the establishment of group norms. In our past experience with computer conferencing, norms are usually created and enforced by "peer pressure". We would like to suggest a few that we feel are important.

Approach "speaking" in the Forum as you would speaking at a town meeting. It's easy to forget, when typing away in your home or office, that you have a large audience "listening" to you.

Since this Forum constitutes "reproduction by electronic means", transcribe copyrighted material only with permission of the author and with the copyright information intact.

Participants are requested to register in the Forum under their real names. Some conferencing systems and "bulletin board" programs allow the use of "handles" or pseudonyms. We think it is important that entries in the Forum are

attributable to the individuals entering them.

This conference is effectively open to the public. Any part of the Forum may be reproduced without permission; please give credit to both the author and the Forum itself.

Illegal or unethical use of the Forum is strictly prohibited. Dissemination of such things as telephone credit card numbers or software outside the public domain cannot be tolerated. This is for the protection of the Forum, and any such action will result in the revocation of participation in the Forum.

Future Enhancements

The software controlling the Forum is continually evolving. It is also very new; consequently it is admittedly limited in scope. The Forum organizers hope to expand the capabilities greatly to aid in its use. The following enhancements, among others, are planned:

Electronic mail. This would allow private messages between Forum participants, as opposed to public items.

Organization by topic. The Forum organizer would assign topical categories to the items, so that they could be searched for by topic.

Searches by string match. The titles, items, and responses could be searched for a particular key word or phrase.

Upload/download of software. Participants could contribute and/or receive public domain software through the Forum.

Conclusion

The use of microcomputers in the preschool setting is relatively recent. The Electronic Forum on Young Children and Computers provides an opportunity for those involved in the selection, evaluation and implementation of computer-related activities to share and learn from one another's experiences. It is hoped that the Forum will promote thoughtful decision-making based on the developmental needs of children, as well as providing practical assistance.

A Short Introduction to Telecommunications

The term TELECOMMUNICATIONS can include everything from telephones to TV. This primer discusses the narrower interpretation of "computer communications".

Although computers are very handy devices by themselves, they become much more useful when they can communicate with each other. This opens up many possibilities, including having a problem worked on by many computers simultaneously, controlling devices in remote locations, and disseminating information. In fact, this handbook was printed by transmitting the text from a microcomputer to a large mainframe and from there to a high-speed laser printer.

There are a number of methods of interconnecting computers. The most popular method is through the use of regular telephone lines and modems. The MODEM (which stands for "Modulator/Demodulator") is a device which converts bits of data into a series of tones. These tones are capable of being transmitted across a telephone connection to another modem, which turns them back into bits of data. This is the method used when communicating with the Forum.

When enough computers and terminals are concentrated within a small enough area to make it economically viable, a Local Area Network or LAN can be used. Instead of telephone lines, a LAN typically uses coaxial cable (similar to cable TV wire) to interconnect the various machines. This gives the advantages of less cost (since the phone company isn't being paid) and much higher data speeds. This is only feasible within a building or campus, since it is usually illegal to pull wire over public lands. The Ethernet system is one common LAN.

Another alternative for more geographically dispersed machines is a Wide Area Network. Wide area networks are constructed by locating switching computers in large cities and interconnecting them with high-speed leased telephone lines, microwave links, or satellites. These networks are regulated by the government because of their size and geography. A wide area network can often provide a less expensive way of communicating with a distant machine than by using modems and long distance calls, but usually requires that the called party have a direct connection with the network and pay large fees for the privilege. Some examples of wide area networks are Telenet, Tymnet, and ARPAnet.

Services such as CompuServe and The Source aren't really telecommunications facilities themselves, but rather are computers which are accessible via telecommunications facilities. They offer a wide range of services such as news, airline reservations, and "CB-style" conversations.

The Electronic Forum is currently only accessible by way of a modem and a telephone call. It is hoped that as the state of the art in telecommunications improves, it will be possible to use it via a faster and less expensive medium.